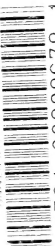


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INITIATIVE IN EVOLUTION

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BY

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AUTHOR OF "USE—INHERITANCE," "DIRECTION OF HAIR IN ANIMALS AND MAN,"
"THE SENSE OF TOUCH IN MAMMALS AND BIRDS," ETC.

WITH NUMEROUS ILLUSTRATIONS

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PREFACE.

THE Great War imposed on speculative biology a moratorium as in the long vacation of lawyers, in which are causes left over to the next term. And so the old case Lamarck *versus* Weismann was not heard in the Courts of Science during the war. In the present term it is due to be heard afresh, and at some future date to come up for settlement. The chapters that follow comprise some of the pleadings on behalf of the plaintiff and are part of the brief of a junior counsel. This adjective, alas ! signifies not the years—for such are often old enough to be the fathers of the leaders—but the standing and attainments of a junior. But in the open Court of Science, and on suited occasions, it may be the business of a junior to question, in the interests of his client, the authority even of Attorneys-General and Lords Chief Justice. In matters of thought and inquiry it is useless to retreat within a stronghold and bar the gates. It may be satisfactory to himself for one Milner to write a book on behalf of a certain body of doctrine and call it *The End of Controversy*, but the book should have held the sub-title *The End of Progress*. The Newtons, Pasteurs and Darwins have seldom wielded the weapon of controversy, though the triumph of *The Origin of Species* would have been slower without the aid of Darwin's brilliant champion and candid friend. But, if the leaders seldom need such help, for the Gibeonite it is a matter of course and simple necessity. With all the urbanity due to the great subject-matter should this pleasant duty be performed. Who would not prefer to the fierce Spaniard the genial Portuguese, discussing all subjects without rancour, and lover of bull-fights though he be, taking care to wrap in cork the horns of his fighting bulls ?

The earlier chapters treat of the arrangement of the mammalian hair, which has occupied my attention for over twenty

years, and this has led straight to the other subjects, because of their bearing on Lamarckism and Initiative in Evolution. The tentative conclusions reached years ago have been strengthened by further knowledge and reflection, and perhaps by certain criticisms. The furrow ploughed may have been lonely, but the pursuit has not been without the mild pleasure of seeing fresh scattered portions of the field coming into their natural order. The resulting state of mind resembles that of a certain Mr. Burke recorded in the annals of a golf club, second to none, the Ancient, and now Royal Blackheath, among whose minutes appears the following :—

“20th September, 1834.

Present, Mr. Burke, *Solus*.

The dinner was good, wine abundant, and the utmost harmony prevailed. The want of grouse was severely felt this day.”

It is written on page 101 of the *Chronicles of Blackheath Golfers*.

My debt to such writings as those of Professors Arthur Keith, Woods Jones, Graham Kerr, and Professors Sherrington, Starling, Schäfer, McDougall and Ward is too obvious to the reader to need more than a bare mention.

I have to thank one critic, Miss Inez Whipple, now Mrs. H. Wilder Harris, for her able if hostile criticism of two former books of mine which has been of use in this one ; and Mr. R. E. Holding for good help extending over many years in the preparation of the illustrations, and for many a good suggestion.

W.K.

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CHAPTER I.

FROM KNOWN TO UNKNOWN

UPWARD—still upward—still upward to the highest! Such is the claim of modern man for the story of himself and the lower inhabitants of the globe. The zoologists have gone so far as to confer upon him the surname *Sapiens*—*Homo Sapiens*. Learned indeed he is, and heir of all the ages, but whether or not his assumed surname be warranted the doctrine of descent with modification can never again be questioned. The work of Darwin was crowned when he compelled a general acceptance of that doctrine, and now the Descent of Man and the Ascent of Man are equivalent terms for a natural process which has converted man from a thing to a person, and is the foundation of all modern thought. The biologist works secure in the knowledge that he is studying some portion of a chain of life stretching back for incalculable ages, and is not careful to produce those missing links demanded by the once formidable foes of his fundamental principle. Haeckel may announce that *Pithecanthropus Erectus* of Dubois is truly a Pliocene remainder of that famous group of highest Catarrhines which were the immediate pithecoïd ancestors of man. This may or may not be true, but if true it makes the descent of man from a lower stock none the surer, the increasing verification of which is not found to rest on missing links.

Many of the discoveries of modern science are made by proceeding from known phenomena to the unknown, or, more precisely, from the well-known through the little-known to the hitherto unknown.

As to the validity of knowledge it is enough to say this—and pass on—all our knowledge is provisional and imperfect, and much of our ignorance is as transient as ourselves.

There are two chief ways in which historians deal with their subject-matter, though the moderns combine them. When oral tradition gives place to written records the lineal descendant of the bards and annalists collects his scanty authorities and compiles his story from them from beginning to end. The Anglo-Saxon Chronicle of Bede and Alfred, the Book of Howth, the works of Giraldus Cambrensis, the Chronicles of Froissart and the Memoirs

of de Comines were composed in the only way that was then possible. But the muse of history entered on a deeper and more fruitful course when about ninety years ago the study of documents became an essential feature of historical work. It was then that the historian grew up, entered upon his finest inheritance and assumed his Greek title, Enquirer, Student of facts, Man of research. He is now nothing if not a man of science as well as of letters. With a wealth of documents within his reach so great that the 3239 Vatican cases full of them formed by no means the richest collection in the archives of Europe, he proceeds to read backwards correctly what many an earlier annalist read forwards falsely. "We are still at the beginning of the documentary age which is destined to make history independent of historians, to develop learning at the expense of writing, and to accomplish a revolution in other sciences as well."¹

The Historian a Biologist.

It is not too much to say that he who studies history, national, political, constitutional, ecclesiastical, military or economic is as much a biologist in the widest sense as the botanist and zoologist. Indeed these were till recently termed students of natural *history*, until the advance of knowledge gave us the various special groups of workers, conveniently called biologists. Though the study of human history by documents is an essential part of the historical method and the student may read *his* subject backwards, this would not of itself warrant the technical biologist in doing so, even though he be a child of Nature and part of her—"Nature's insurgent son." But some reflection on the facts of certain provinces of science affords ample justification for the method. It is chiefly in questions of origin that it avails, while it fails in that form of research by experiment which is the glory of modern science. A few examples of the process of passing from the known to the unknown will illustrate the method.

Darwin.

Much of the *Origin of Species* and all of the *Descent of Man* was founded on this method; thus in the former the conceptions of struggle took their main rise from the work of Malthus on Human Population, and of variation from domesticated animals and plants, and this is true also of Wallace. A mere glance at the divisions of *The Descent of Man* shows that it could never have been attempted in any other than the backward way.

¹ Acton. *A Lecture on the Study of History*, p. 19.

Geology.

In their researches on the crust of the earth Playfair, Hutton and Lyell did not pursue them by going down a coal mine till they came to the lowest available beds and work upward from these to the highest. Though for purposes of exposition a great geologist, as Sir Archibald Geikie, may expound the making of the earth from the lowest to the highest levels, and Professor Bonney tell us the *Story of our Planet* from beginning to end as if he had watched it unfolding, Lyell in his *Principles of Geology* shows how the studies of his great province began. There we have the backward reading of its story pursued by himself and other great ones, and where it led them. Commencing with the Pleistocene period and passing through Neocene and Eocene periods through the Mesozoic Era and its cretaceous, jurassic and triassic systems to the Newer Palæozoic Era and its Permian, carboniferous, and Devonian systems, the older Palæozoic Era and its Silurian Ordovician and Cambrian systems, he reaches the unknown. But before all this patient research and its record is reached he treats, as he must, of consolidation and alteration of strata, of petrification of organic remains, elevation of strata, horizontal and inclined stratification, of faulting, denudation, upheaval and subsidence as they combine to remodel the earth's crust. The title of his classical work is significant—*An Attempt to Explain the Former Changes of the Earth's Surface by Reference to Causes now in Operation* (it may be noted that in 1830 they were fond of capital letters and of underlining their words). If these great men had been condemned to the sole use of the method of the annalist in his treatment of human history, that of the coal mine in geology, this great province of knowledge would never have been what it is to-day.

At this point I think it well to state that this illuminating principle of Lyell is pursued in nearly all the matters of fact and their interpretation contained in the following chapters, so that from time to time I shall have to employ the verb, coined for the purpose, when I attempt to "Lyell" them on behalf of Lamarck.

Anthropology.

The anthropologist could hardly make a start with his research, if, knowing nothing of his own anatomy, physiology, customs and beliefs, he tried to interpret the physical features, habits, manners, customs and rites of an African tribe. Without such prior knowledge he would find it a profitless task to journey to the banks of the Zambesi and bring back any intelligible history of the aborigines. If he did not know the games of a European child how could he

understand the variants of them such as the writer of *Savage Childhood*¹ expounds so well ?

The Sources of Rivers.

To trace the course and source of a river is a simple task through the work of modern geographers, and such a pursuit illustrates well the two methods here considered, but it is doubtful if any river was ever traced originally from its fountain head to its mouth. The backward way of such exploration, from the nature of the case, has always been taken, and men have traced the more or less finished products of the lower stretches, backward, still backwards, even as in the Indus, to the still-unknown. The earliest thinkers and seekers in the plains of Bengal were familiar with much of their great sacred and composite river as it flowed into its delta. Slowly, laboriously, here a little and there a little, they learned its stupendous story. They found the plateau of Tibet in the Himalayas where the twin-sisters, Brahmaputra and Ganges were born, and saw how from the one high cradle they parted on their eastward course for a thousand miles with the mountain-chain between them, and how, coming together again, the one descending through Assam and the other flowing through the plains, reinforced by the Jumna, they united to form the Ganges-Brahmaputra. A great subject indeed for the early geographer, but one which he could only follow in the backward way. Again how well known and revered in Egypt was the Nile for thousands of years before its source in Victoria Nyanza could be traced, even though Nero might send his explorers as far as the marshes of the White Nile, and Ptolemy's search for it might lead him to guess the riddle, and assign it to two great lakes !

Genealogy.

Not many of us can trace our ancestry in the direct male line to the 8th century by authentic and written documents as did a Hebrew friend of mine, thus effectually meeting the doubts of a prospective brother-in-law who asked him as to his fitness to enter a family which was able to produce a stray peer of the realm in its roll. On the other hand a man who has lost his parents in childhood may know nothing of them but that his father's name was A. Mann, and that he was buried in a Kentish churchyard. He may go on a pilgrimage and find there recorded the fact that A. Mann was the son of A. Mann, Gent, who came from Northumberland. He will doubtless make another pilgrimage and find there a large vault,

¹ *Savage Childhood*, Dudley Kidd.

and over it an imposing record of many a Mann, and yet further he may go, and from the Heralds' College find out the still earlier derivation of his ancestors.

Detection of a Crime.

There are two chief ways of detecting a crime. By oral evidence from eye-witnesses or confession of the accused you may get direct proof, though even here are pitfalls from careless and hasty witnesses on the one hand, or on the other from a strange perversion of mind of the confessing person which is well enough known to forensic medicine. You may thus bring home to the accused his guilt by the method of the annalist. Or you may employ the more common method of studying circumstantial evidence ; the story of the crime is read backwards and a verdict of guilty is given. This is the main stuff of which the prevalent detective story is composed.

A Parable.

A plain parable may well conclude this chapter.

As I mused on the chain of life I found a piece of whipcord which had been lying by for twenty-five years since some of it was used for rigging a model yacht, and this very efficient product of human art seemed to speak to me on the subject of my musings. Perhaps if Huxley could extract from a piece of chalk or lumps of coal two magnificent expositions on geology and biology, this little trifle of cord might afford a text on a way of looking at living things which should be useful in this old case of Lamarck *v.* Weismann—and others.

Should I learn the story of the whipcord forwards like an annalist, or backward like a modern historian ? Clearly it could be done in a measure by either method. Here was a highly finished product of which either might furnish the story, and of which, we may suppose, I knew nothing. I tried the backward way, and by the aid of a needle began to unravel it. The cord was as good as if just made, slender, strong, twisted, with some glazing on the twisted threads. It showed three main bundles, and each of these was composed of two smaller ones. The substance of all these six was found when examined with a lens to consist of minute silky fibres varying from a quarter of an inch to an inch in length. This was all I could learn without a stronger magnifying power or a chemical analysis, and the direct search was at an end. I gathered since then that the first three bundles were called "strands," and the two composing each of these "yarns," and that the fibres were from a plant called hemp. This did not carry the story deep or far, and illustrates

how often in the backward method facts have to be supplemented by inference. But I had learnt some undoubted facts and some inferences from them nearly as certain. Some mind of man had conceived and hands carried out the division of the bundles of fibres into three strands, had twisted them somehow so as to reduce their length by a quarter and yet not far enough to rupture them, and had thus fitted them the better for their purpose by a reinforcement of tensile strength due to the twisting. I could also see that this same mind had seen it better to divide each of these strands into two yarns before the final twisting, and that in framing the yarns the silky fibres of the plant had been squeezed together by some powerful agency and yet not disintegrated, and that the finished product had been immersed in a protective substance which gave it a slight glaze. In short, I, though a child in these matters, read much of the story of this cord in terms of mind dealing with given organic matter. I may add that I did not imagine myself a little Paley, and that I do not intend to "take in" the reader as to the argument from design and final causes, even though this parable may feebly resemble Paley's study of a watch. The conclusion was perfectly clear that certain directing grey cells of a certain brain had interfered with and acted upon some plastic vegetable matter, and one could at the "strand" stage, the "yarn" stage, and the "fibre" stage see mind writ large.

The Forward Way.

The limits of the former method are obvious, but I might also attempt to follow the little story as a crime is followed and described by eye-witnesses. So I go to an old-fashioned rope-factory and ask the foreman questions about the making of twine, cords, ropes and cables. He shows me bundles of hemp; he calls them Russian, Italian or American, and goes on to tell me how the fibre is "heckled" or combed, how "tow" is separated from "line," and how the yarns are pressed together and twisted, how they are at first rough and bristly, and are then dressed, polished, and "sized" with such a starch as that of the potato. When I proceed to ask him about the plant itself his interest flags, and he becomes vague. He says, "You had better ask the Head, young Mr. X., he knows these things better." I find the Head with his golf clubs over his shoulder and about to start on his "business," and he is polite, but says he knows very little about the origin of his hemp. "You should go over the way and ask Messrs. Y. if they will let you see the expert who advises them in their business, he will know." The expert is at home and kindly and fully describes to me the early home of

the wild *Cannabis Sativa* in a moderate climate of Asia, the rich soil it needs for its growth and the various countries of the world into which it has been introduced ; and the bast-fibres of the bark of this plant which from remote antiquity has supplied the silky stuff. He then tells me how the stems are dried and crushed, and then of the important stage of fermentation or " retting " in water, how they are again beaten in a " break," then rubbed and " scutched," and finally " heckled " or combed ; and, as to analytic chemistry, he tells me that the chief constituent is cellulose. This quest is now over and I know much I could not find out by the backward method, though the dependence of its rival upon the presence of honest and capable eye-witnesses is not less obvious. It is not alone in ecclesiastical history that cheats and forgers of documents exist. In the world of Nature there may be, for all we know, biological False Decretals that may lead us far astray, such perhaps as *Amphioxus* and *Archæopteryx*, and the *Pseudo-Isidore* who produced them may yet be discovered.

CHAPTER II.

REVIEW OF THE POSITION

THE modern story of the theory of organic evolution shows certain important dates—1859, 1880, 1894, 1895, 1899 and 1909. These begin with the *Origin of Species* and end with the publication of a volume in commemoration of its jubilee, when most of the leading students of evolution united to render homage to Darwin. The year 1859 has been so often and so worthily treated that it is enough here to say that the fifty years between the issue of the work of Darwin and Wallace and 1909 saw a greater revolution in biology, speculative and practical, than any period so relatively brief had ever seen.

In the year 1880 the "coming of age" of the *Origin of Species* was celebrated. On the 9th of April at the Royal Institution an address was given by the powerful friend, champion and candid critic of Darwin, and before the scientific and educated world Huxley was able to say with his own force and directness: "Evolution is no longer an hypothesis, but an historical fact." It may be noted in passing that Darwin's theory of natural selection is not referred to in the address. Challenges and opposition from various quarters met this confident claim of the formidable speaker, as doubtless he desired, but the work of the succeeding half-century has done little or nothing that does not establish that claim. It is hardly to be doubted that if in the jubilee-year, 1909, Huxley had been alive on this earth, instead of elsewhere, his eloquent voice would have been heard to declare with emphasis equal to that of 1880: "Selection is no longer an hypothesis, but an historical fact." Some such statement, with the *imprimatur* of a great name would have removed from the jubilee-volume that slight aspect as of a Dutch chorus¹ which is apparent in it. A remark of Kelvin's

¹ The above remark as to the jubilee-volume needs to be explained and justified. In it there is an important essay on each of the great provinces of Weismann, Mendel and de Vries, and in each of these the highest living exponent speaks, Professors Weismann, Bateson and de Vries. Bateson expresses admiration for Weismann's destructive work, but shows plainly that he holds it to have failed in its fundamental purpose. Nevertheless, by a neat *tour d'adresse* he adopts Weismann's uncompromising attitude on the inheritance of acquired characters, which happens to agree exceedingly well with his own

when he was conferring a medal of the Royal Society on Huxley may illustrate what has been said above. He said that they must all be thankful to have still among them that champion of Evolution who once bore down its enemies, but was now possibly needed to save it from its friends. It may be regretted that it was not so in 1909.

Three Blows to Darwin.

But other historic events are more relevant to my immediate purpose than these.

Three blows were delivered against Darwinism in the years 1894, 1895 and 1899 by Prof. Bateson, Weismann, and again Prof. Bateson, under which it seemed to reel, but from which it is more than likely it has derived but greater strength.

scheme. He has but one insignificant reference to de Vries on p. 95 where he finds help for his doctrine.

Weismann makes no reference to Mendel or de Vries. De Vries makes none to Weismann or Mendel, but without stating it in his essay he is known to be in opposition to Weismann's dogma on the inheritance of acquired characters. These three eminent biologists would thus seem to have worked on diverging lines. The two first agree heartily, Weismann explicitly and Bateson by implication, as to the forbidden doctrine, "on the ground that it closes the way to deeper insight"—in other words their mutually destructive theories. So it stands thus in the book—Weismann throws over Lamarck, Mendel and de Vries; Bateson throws over Weismann (as again in 1914) and de Vries; de Vries ignores Weismann and Mendel.

Dr. Lock in his book on Variation, Heredity and Evolution, 1906, says that Weismann practically ignores the evidence of Mendelism in heredity, and adds, p. 261, "But at the next step the Mendelian parts company with Weismann."

One cannot avoid noticing, incidentally, that the vast mass of work of the biometricians led by Galton, Weldon and Professor Karl Pearson is conspicuously absent from the book. Prof. J. Arthur Thomson says that there should be no opposition between Mendelian and Galtonian formulæ, "they are correlated, and ultimately they will be seen in complete harmony as different aspects of the same phenomena. But it is simply muddleheadedness which can find any opposition between a statistical formula applicable to averages of successive generations breeding freely, and a physiological formula applicable to particular sets of cases where parents with contrasted dominant and recessive characters are crossed and their hybrid offspring are inbred." (a) concerning which see the Preface to Bateson's *Mendel's Principles of Heredity*, 1902, with remarks on some of the Galtonians.

Considering the mole-like and persistent work of the biometricians, some who are at present keeping well-ordered lawns may find some day a few disturbing heaps of facts. I am reminded here of an historic duel, Oxford v. Cambridge, which took place soon after the introduction of Mendel's discoveries into England at the London Zoological Society, when Prof. Bateson expounded them with enthusiasm and when Weldon repelled them with cogent and incisive arguments. The duel lasted nearly two hours and that was not too long for the audience, but one has the impression that some of what Professor Thomson calls muddleheadedness must have been somewhere existing. However, the duel was fought when Mendelism was young.

(a) *Heredity*, p. 374.

BATESON.

In 1894 Prof. Bateson published his large and important work, *Materials for the Study of Variation*. As a distinguished student and teacher of biology he found the received doctrine of evolution in straits as regards the factor of natural selection in producing specific differences, as indeed happened to another equally eminent man during the next year. He was profoundly discontented as to the origin of specific differences on the theory of direct utility of variations, and he said "on our present knowledge the matter is talked out."¹ He threw over the study of adaptation "as a means of directly solving the problem of species." He came to the conclusion "Variation is Evolution," and affirmed that the readiest way of solving the problem of evolution is to study the facts of variation. Hence arose this notable book, and hence one of his trenchant statements to the effect "that the existence of new forms having from their beginning more or less of the kind of perfection that we associate with normality, is a fact that once and for all disposes of the attempt to interpret all perfection and definiteness of form as the work of selection,"² and "Inquiry into the causes of variation is as yet, in my judgment, premature."³ It will hardly be denied that a work which contained such statements as these from such a source seemed momentous in its influence on the fate of Darwin's theory. Prof. Bateson yielded to none in his loyalty to Darwin, as far as he knew himself, and here he is as candid as Huxley, and he declares that in his treatment of the phenomena of variation is found nothing which is in any way opposed to Darwin's theory. The shade of Darwin might nevertheless have looked with some misgiving at this man over against him with a drawn sword in his hand, and have asked gently, "Art thou for us or for our adversaries?" Prof. Bateson's work chiefly requires to be considered here because to any reader of it there must come the conviction on the one hand of Prof. Bateson's merits and power, and on the other of his limitation as a student of organic evolution. In 1894 is evident already an exclusive attention to structure rather than function, to anatomy than physiology; the anatomical leaven in doctrine has leavened the whole lump. For him physiology of animals and plants does not exist, or at the best is the outcome of structures which arise through variation and selection. This, if I may say so, is as much his strength as his weakness. There have been other great biologists, such as Geoffrey Saint-

¹ *Materials for the Study of Variation*, p. 5.

² *Op. cit.*, p. 568.

³ *Op. cit.*, p. 78.

Hilaire and Richard Owen, of whom this is true. If that were all one would not wish the reader to be troubled with any criticism of one's betters, indeed such remarks as are here made do not amount to criticism at all, but just plain text-book statements. It is also evident that the outlook of Prof. Bateson was being prepared for a revelation which had not yet come, in which he took a prominent, if not dominant part, I mean the great rediscovery of Mendel's work by de Vries, Correns and Tschermak and himself in England. His keen and close attention to anatomical structures was preparing his mind for the germinal conceptions of unit-characters, dominance and segregation. The intensive cultivation of the fertile field of genetics proceeded apace, and Prof. Bateson in his contribution to the jubilee-volume of 1909 betrayed the trend of his devotion to a system of *distribution* rather than formation of the qualities of an organism. The organism as an historical functioning, striving being, had receded once for all from his vision. He hazarded the suggestion in *Heredity and Variation in Modern Lights* that "variation consists largely in the unpacking and repacking of an original complexity," and that "it is not so certain as we might like to think that the order of these events is not predetermined." Incidentally one may remark that, *malgré lui*, Prof. Bateson stands forth as a modern Paley as does Weismann in his great rival and opposing scheme. It is true that he says "I see no ground whatever for holding such a view, but in fairness the possibility should not be forgotten and in the light of modern research it scarcely looks so absurdly improbable as before." Having drawn the sword he threw away the scabbard in 1914 when he occupied the presidential chair of the British Association of Science at Melbourne and Sydney. He had said in 1894 in his book on variation as stated before, "Inquiry into the causes of variation is as yet, in my opinion, premature," and then in 1914 at Melbourne, after twenty more years of study of the subject in the Mendelian direction, "It is likely that the occurrence of these variations is wholly irregular, and as to their causation *we are absolutely without surmise or even plausible speculation.*" (my italics).¹ So, on this fundamental point, he stands where he did when he began the study of variation, but apart from this point he again threw out his suggestion of 1909 as to the unpacking and repacking of an original complexity. At Melbourne he said, "Lotsy has lately with great courage suggested to us that all variation may be due to such crossing. I do not disguise my sympathy with this effort."² *All variation!* He said later, "In spite of seeming per-

¹ *Nature*, 1914.

² *Op. cit.*, Aug. 20th and Aug. 27th, 1914.

versity, therefore, we have to admit that there is no evolutionary change which in the present state of our knowledge we can positively declare *not due to loss*.”¹ (Italics mine.) These two statements of 1914 are enough to show that the biologist of 1894, 1899, 1909 and 1914 has evolved in a definite line, and it is to his honour that he has remembered “to thine ownself be true.” But he is not so true to himself in his scorn of those who propound theories. For myself I would give little for the biologist who did not hold or propound some theory. What was the penultimate and stirring message of the gifted G. B. Howes? “We live by ideas, we advance by a knowledge of the facts.” The self-denying ordinance affirmed and reaffirmed by Prof. Bateson is not observed even in the Melbourne and Sydney addresses. In the former, he says “at first it may seem rank absurdity to suppose that the primordial form or forms of protoplasm could have contained complexity enough to produce the divers types of life,” and asks us to open our minds to this possibility. Again “I have confidence that the artistic gifts of mankind will prove to be due not to something added to the make-up of an ordinary man, but to the absence of factors which in the normal person inhibit the development of these gifts.” And at Sydney, “Ages before written history began, in some unknown place, plants, or more likely a plant of wheat lost the dominant factor to which this brittleness is due, and the recessive thrashable wheat resulted. Some man noticed this wonderful novelty, and it has been disseminated over the earth. The original variation may well have occurred once only in a single germ,” and “so must it have been with man.”²

These are three stupendous stretches of imagination and theory in one address, which would have been the poorer if they had not overcome the accomplished speaker's dislike of the theories—of others. If they are not ideal constructions of a high order I do not know the meaning of that term. They are worthy of Weismann the Prince of ideal constructionists. Prof. Bateson might indeed be another Newton with his *Hypotheses non fingo*.

Turning to another important biological doctrine one can see what it may be legitimate to call a bi-phyletic parallelism in the biological make-up of Prof. Bateson. Again is seen consistency of view and loyalty to his first love. Two references from these addresses will be enough to introduce the point.

At Melbourne, “We thus reach the essential principle that an organism cannot pass on to offspring a factor which it did not itself receive in fertilization.”³

¹ *Nature*, 1914.

² *Op. cit.*, 1914.

³ *Op. cit.*, 1914.

At Sydney, "The factors which the individual receives from his parents, and no others, are those which he can transmit to his offspring"¹—in other words the doctrine of the inheritance of acquired characters is estopped. As to this he speaks in 1909 more doubtfully on p. 90 and on p. 95 almost dogmatically.² There is just a convenient haziness of meaning in the term "factor" with which some play might be made, but, taking it to mean what the context indicates, an acquirement made by the individual during its personal life, we have pretty clear evidence that Prof. Bateson will have nothing to do with the inheritance of acquired characters as that doctrine is understood by the unsophisticated biologist. This opposition should be counted unto him for righteousness rather than the reverse, for it falls into line with his life's work to which he has given of his best.—*Vestigia nulla retrorsum*. The point reached here which concerns my purpose is that the orthodox Mendelian still knows nothing of the cause or origin of variation, and will have none of Lamarck.

This consideration of Prof. Bateson's work of a quarter of a century has been necessary for showing how the work of Weismann and himself diverge gravely and yet meet at one point, and the year 1899, being linked with 1894, has been taken out of its chronological order.

It may be permitted perhaps to say respectfully to the Mendelians in the words of the dying father in the fable, "Dig, my sons, dig in the vineyard." If they follow still the course of the sons they may find more gold than they have found already and perchance that which is better than gold. But they will produce from it nothing that is not there.

Two Parables.

Here gentle reader (I seem to remember this style of address in the stories of our youth) pause with me in a little oasis of the desert-stage of our journey, and brush off some of the dust, while I briefly narrate two incidents, but I pray you also not to leave me in the midst of them so that you may escape the next short stage.

A traveller, small and insignificant, armed only with an oak cudgel, was passing alone through a South American forest. As he trudged forward he noticed at a certain point in the path (shall we call it 1894-1899?) that a jaguar was watching him and was about to break his truce with man. He turned off to the right and there he saw a puma and this too

¹ *Nature*, 1914.

² *Darwin and Modern Science*.

seemed to meditate evil. He hastened forward just in time as his two enemies sprang at him, and these two near relatives were locked in mortal grip—and so he passed on safe!

The reader, naturalist or layman, can point the moral for himself.

At the battle of Trafalgar, while fighting was in full progress on one of the ships, some sailors were occupied in throwing overboard the bodies of those who had been killed. A poor Scotchman badly wounded and hardly conscious was taken up by two seamen, an Englishman and an Irishman, and as they were about to throw him overboard his feeble voice was heard to say "I'm no deed yet." "What's that?" said the Irishman. "I'm no deed yet"; "Arrah, the doctor said he was dead, over wid him," said the Irishman.

Weismann.

During the period 1894-1899 there was a dramatic proclamation on the part of one of the greatest living biologists, which was, in the cosmos of biology, what the Proclamation of the Empress-Queen of India was in 1876, and it is not out of place to remind the reader that the fates of the two Imperial utterances have been somewhat different. In 1895 Weismann issued his official statement of doctrine which was to crown the work of his life, an essay on *Germinal Selection*. From Freyburg in November, 1895, he wrote a preface to his address delivered on September 16th in that year to the International Congress of Zoologists at Leyden. This formed an epoch in biological thought and there lived none so well qualified as Weismann to stand forth as its interpreter. The well-translated, forcible language, and lucid thought leave the reader in no manner of doubt as to his meaning. It took a wider form in his final book on the *Evolution Theory*, but the germinal and essential thoughts of the latter were contained in the former. From 1895 onwards the praise of Weismann was in all the churches. Probably no modern worker in the fields of heredity and evolution has done so much as Weismann towards raising great issues and removing some ancient misconceptions; but it is one thing to raise great issues and another to solve them. In this he has signally failed, nevertheless biological theory would be the poorer if he had not made the attempt. Reflection, the work of other biologists, and the remorseless hand of time have shaken the edifices then raised. I will here only bring forward a few of the most illuminating passages of the 1895 essay, and then refer to the handling of Weismann's work by Romanes.

This trenchant essay contains fifty-seven pages, of which reasoning forms the greater part. As to the facts it might well pass for an essay from Professor Poulton's pen, for Weismann's special province of insects occupies nearly all the evidence from facts. Outside this highly specialised group there are exactly fifty-three lines, or one and a half pages, which deal with other animal groups, and there are four casual allusions to plants occupying twelve lines in all! In the essay of 1909 on the Selection Theory this treatment of animated life in the world is improved upon and thirteen out of its forty-seven pages refer to animals outside his favourite group of insects. Such exclusive dealing with these little things does not commend the reasoning, at any rate to a neo-Lamarckian; such a circle is too select for him.

Weismann's Twelve Points.

The most striking remarks from the 1895 essay on germinal selection are :—

1. "The real aim of the present essay is to rehabilitate the principle of selection. If I should succeed in reinstating this principle in its imperilled rights, it would be a source of extreme satisfaction to me."¹

2. Speaking of the whole theory of selection he claimed to have found a position "which is necessary to protect it against the many doubts which gathered around it on all sides like so many lowering thunder-clouds."² And he speaks on page 26 of "the flood of objections against the theory of selection touching its inability to modify many parts at once."

Thus Weismann stood forth to defend the crumbling edifice of Darwinism and threw his shining sword into the scales, a scientific Athanasius "contending for our all." Again is seen a friend of Darwin from another camp than that of Mendel, whose support needs to be received with some caution. *Toujours en vedette* is a useful rule.

3. Speaking of adaptedness in animated nature he says, "We know of only one natural principle of explanation for this fact—that of selection."³

4. "Germinal selection is the last consequence of the application of the principle of Malthus to living nature."⁴

5. "Without doubt the theory (Germinal Selection) requires that the initial steps of a variation should also have selective value."⁵

¹ Preface to *Germinal Selection*, 1895, p. xii. ² p. 38. ³ p. 43. ⁴ p. 43. ⁵ p. 38

6. "Something is still wanting in the theory of Darwin and Wallace which it is obligatory on us to discover if we possibly can. We must seek to discover why it happens that useful variations are always present."¹

7. "It is impossible to do without the assumption that the useful variations are always present, or that *they always exist in a sufficiently large number of individuals for the selective process.*"²

8. "*Some profound connexions must exist between the utility of a variation and its actual appearance, or the direction of the variation of a part must be determined by utility.*"³

9. That "germinal selection performs the same services for the understanding of observed transformations . . . that a heredity of acquired characters would perform without rendering necessary so *violent an assumption!*"⁴ (Italics mine.)

10. Weismann speaks warmly of Professor Lloyd Morgan for his caution and calmness of judgment but complains of him that he "has not been able to abandon completely the heredity of acquired characters."⁵

11. As to passive effects of environment, etc., he says "the Lamarckian principle is here excluded *ab initio.*"⁶

12. "It seems to me that a hypothesis of this kind (Lamarckism) has performed its services and must be discarded the moment it is found to be at hopeless variance with the facts."⁷

I have only to add here that several years ago I wrote to Weismann drawing his attention to some facts I had observed which seemed to me to be instances of use-inheritance, and I received a reply in polite but brief and Prussian terms to the effect that the facts referred to must be capable of some other interpretation, for *the machinery for their transmission did not exist.*

Each of these twelve quotations from Weismann's essay is important from the present point of view, and shows how far neo-Darwinians are likely to promote the greater glory of Darwin, and though more than a quarter of a century elapsed between this essay and his death Weismann was not the man to have repudiated any of these strong statements.

Lighthouse Value.

I hope at this point a small digression is not out of place in order to introduce an aspect of Weismann's work which is not usually appreciated. A child is aware of the great and lesser lights that rule the day and night, but for modern man these are not

¹ p. 15. ² p. 14. ³ p. 18. ⁴ p. 40. ⁵ p. 56. ⁶ p. 11. ⁷ p. 17.

sufficient. Accordingly he has invented from immemorial times his oil lamps, rushlights, tallow and wax candles, gas and electric light for the illumination of his streets and houses. Prehistoric man did not seem to need them, as he thought. These useful examples of applied knowledge were obviously brought into use for showing man better where he was going and where to go, what he was doing and what he wished to see. I hope this trite remark may be pardoned, for there is another form of light which suits my purpose of illustrating the aspect of Weismannism referred to above, that is the light of a lighthouse. The ancients in their crude way saw the need for this and as far back as the days of Ptolemy II. a tower to give light was erected on the island of Pharos, off the Egyptian coast, and it was called a *pharos*. Man found it necessary, as navigation and seafaring advanced, to use this principle more and more, and on headland, sandbank and rugged coast has built noble structures to aid the sailor in his dangerous course. The oldest and finest of these in Great Britain is the Eddystone lighthouse, built first in 1695 by Winstanley and finally by Smeaton in 1756-9. For what reason is a lighthouse built and placed where it is? For the precisely opposite reason to that of the domestic candle. While this shows you where to go and how better to do your immediate business, a lighthouse is for the main purpose of showing a mariner where he should *not* go. It has no relation to adornment or pleasure. It does not invite you to come in your vessel and admire it. It tells you to go away and avoid the sunken rock or treacherous sands.

I submit here the suggestion with all deference, that the final work of Weismann has lighthouse value of a high order, as to the *modus operandi* of evolution. His greatness as a biologist, his candour and skill in dialectics, have built up a veritable lighthouse which may usefully warn the seeker after the path of evolution that he must turn elsewhere if he would not founder upon a reef of facts.

The two great contributions to evolutionary thought that Weismann has made should be considered separately, the theory of germ-plasm and that of evolution, though the latter seems to be the necessary outcome of the former. But the truth of Weismann's view of heredity does not of necessity require the error of his theory of evolution.

Romanes on Weismann.

For this study the examination of Weismannism by Romanes published in 1893 is of great value. I need only refer here to the main conclusions of that lucid and learned examination.

Weismann's work on the germ-plasm in pursuance of a theory of heredity is pronounced by Romanes to have remained up to 1893 substantially unaltered, though largely added to in matters of detail, and at the present time as far as I gather from a study of the more recent literature this theory holds the field or at least a commanding position in it.¹ Originally he held that the germ-plasm possessed *perpetual* continuity since the first origin of life, and *absolute* stability since the first origin of sexual propagation, but he has shown himself willing to surrender the first postulate, and has himself altered the second. As it stands now it must be admitted that the continuity of the germ-plasm is an interrupted continuity with the appearance of every inherited change; the continuity is theoretical, not actual, and the stability of the germ-plasm is not absolute but of a high degree. We can thus see in the story of this original theory of heredity the lighthouse value of the *pharos* of Ptolemy II.

It is far otherwise with Weismann's theory of evolution. Romanes shows that with the removal of its essential postulate the absolute stability of germ-plasm, Weismann's theory of evolution falls to the ground. He has indeed surrendered much in his later building, his second temple of Solomon, and prominent among these was the claim that the only causes of individual variation

¹ Romanes, *Examination of Weismannism*, p. 115.

"It is doubtful if anything better as to Weismann's theory of heredity can be said to-day than Romanes said in 1893, and inasmuch as these two latter or distinctive postulates are not needed for Weismann's theory of heredity, while they are both essential to his theory of evolution, I cannot but regret that he should have thus crippled the former by burdening it with the latter. Hence my object throughout has been to display, as sharply as possible, the contrast that is presented between the brass ("iron" preferably) and the clay in the colossal figure which Weismann has constructed. Hence also my emphatic dissent from his theory of evolution does not prevent me from sincerely appreciating the great value which attaches to his theory of heredity. And although I have not hesitated to say that this theory is, in my opinion, incomplete; that it presents not a few manifest inconsistencies, and even logical contradictions; that the facts on which it is founded have always been facts of general knowledge; that in all its main features it was present to the mind of Darwin, and distinctly formulated by Galton; that in so far as it has been constituted the basis of a more general theory of organic evolution it has proved a failure; such considerations in no way diminish my cordial recognition of the services which its distinguished author has rendered to science by his speculations upon these topics. For not only has he been successful in drawing renewed and much more general attention to the important questions touching the transmissibility of acquired characters, the causes of variation, and so on; but even those parts of his system which have proved untenable are not without such value as temporary scaffoldings present in relation to permanent buildings. Therefore, if I have appeared to play the *role* of a hostile critic, this has been only an expression of my desire to separate what seems to me the grain of good science from the chaff of bad speculation."

and of the origin of species in the uni-cellular organisms are the Lamarckian factors, just as in the multicellular *the only cause of these is natural selection*. Thus we see standing at the critical date, 1892, the first Eddystone lighthouse of Winstanley, a greater and more important structure than the old pharos.

Germinal Selection.

It can hardly be doubted that one of the "thunderclouds" threatening Darwinism, of which Weismann spoke in 1895, was this examination of Weismannism by Romanes. As the case stood then some fresh strategy was needed if victory for Darwin was to be won, at least so the great leader said. It must be remembered that it was the *personal* selection of Darwin which was held to be in danger. Accordingly germinal selection was brought forth and remained the basis of Weismann's later *Evolution Theory* of 1904 and 1909. Romanes did not live to see or assist in the disproof of this ambitious piece of work so that his "examination" is so far incomplete.

The position of germinal selection is defined in Weismann's statement that "it is the adaptive requirement itself that produces the useful direction of variation by means of selectional processes within the germ." Here it is in a nutshell. The theory itself is consistent, and clearness has been added to the earlier evolution theory by the claim that a struggle for nutriment occurs within the fertilised ovum between the innumerable determinants of the different parts, so that maintenance or victory over weaker determinants takes place. Thus we have a survival of the fittest *in petto* in the germ analogous to that of the individual organisms as we see them. There is of course a resemblance here to the cellular or histonal selection of Roux, but his doctrines are not weighted with the intolerable dogma of the non-inheritance of acquired characters. But ultimately this conception of germinal selection has to come down and bow to the tribunal of facts, and the remark of Weismann on Lamarckism which has been already quoted, "It seems to me that an hypothesis of this kind has performed its service and must be discarded the moment it is found to be at hopeless variance with the facts," confronts the consistent Weismannian. And I venture to say here that germinal selection is represented by the Eddystone lighthouse of 1756-9 erected by Smeaton.

The grounds for this statement are afforded by numerous facts and experiments, to which in the later chapters I propose to add a few fresh ones, and by a growing body of opinion and authority in favour of Lamarckian factors in evolution.

Three "lighthouses" of this metaphorical sort have thus been afforded by the work of Weismann, represented by the Pharos of old, Winstanley's Eddystone lighthouse and that of Smeaton.

Authority.

We have then Weismann and Professor Bateson definitely ranged against the position taken in this volume as to a cause or origin or variation and the inheritance of acquired characters. To these we must add the great weight of Sir E. Ray Lankester's opinion lately given in a reply to Professor Adami that "it is very widely admitted (more correctly "claimed") that no case of the transmission of what are called acquired characters from parent to offspring has been demonstrated in so far as those higher animals and plants which multiply by means of specialised egg-cells and sperm-cells are concerned."

It is not necessary to mention more than these "three mighties" of the biological world.

Many others such as Prof. J. Arthur Thomson and Prof. W. K. Brooks, of Johns Hopkins University, are still unconvinced as to Lamarckian factors and ask for more evidence, and they have many to support them in their opinion and claim. There is often a tone of weariness, as well as wariness in their remarks on the matter.

In favour of the neo-Lamarckian position, with which stands or falls the suggested cause of variation, there is a growing body of opinion, with the mention of which I conclude this review.

1. The accomplished writer of *Form and Function*, Mr. E. S. Russell, says the theory of Lamarck "although it had little influence upon biological thought during and for a long time after the lifetime of its author, is still at the present day a living and developing doctrine."¹

2. Sir Francis Darwin from the Presidential Chair of the British Association of Science in Dublin in 1908 proclaimed his adherence to the mnemonic theory of heredity, foreshadowed by Samuel Butler and inaugurated by Semon, a condition of which is that acquired characters are inherited. This caused much stir in the camp of "our friends the enemy."

3. Observations and experiments at variance with germinal selection and its negative presupposition have been rapidly accumulated from the work of botanists and zoologists who were prepared to appeal to the tribunal of natural processes; though Weismann and some of his followers, with some reason, look upon the evidence from plants as a weak link in the chain of evidence.

¹ p. 215.

Many of the observations and experiments are well-known and only a mere mention of them need be made here, they are such as Mr. J. T. Cunningham's observations on the effect of light on the under surface of flounders, Kammerer's on the changes in the colour of salamanders to surrounding objects, and others by him on certain amphibia and reptiles especially *alytes* held by Professor McBride to be convincing, though the latter are to be repeated at the London Zoological Society's gardens and are therefore *sub judice*—others on brine-shrimps, on the effects of change of food on bee-grubs and tadpoles, and of the change of level of environments of certain cereals—others by Henslow on plants which have never been refuted, and many by the late Prince Kropotkin. The latter have appeared at length in certain issues of the Nineteenth Century in September 1901, March 1912, October 1914, and the last in January 1919, and they deal both with plants and animals, and are too numerous to be mentioned here individually.

Again, Professor Dendy as President of the Zoological Section of the British Association of Science in September, 1914, devoted most of his address to the subject of Lamarckism and firmly claimed as a necessary factor of evolution "the direct response of the organism to environmental stimuli at all stages of development, whereby individual adaptation is secured, and this individual adaptation must arise again and again in each succeeding generation." He also maintains this position in several passages in his important work *Outlines of Evolutionary Biology* published in 1912.

A statement by Professor Bower, President of the Botanical section of the British Association of Science in 1914 should also be noted: "I share it (the doctrine in question) in whole or in part with many botanists, with men who have lived their lives in the atmosphere of observation and experiment found in large botanical gardens and not least with a former President of the British Association, viz., Sir Francis Darwin."

Professor Adami, in 1917, published an original work called *Medical Contributions to the Study of Evolution* in which from his extensive knowledge of the subject he deals with evidence of inheritance of acquired characters in lowly organisms as well as higher animals from the point of view of pathology.

Enough has been stated here to show that the dogma of Weismann or Lamarckian factors in organic evolution, *quâ* authority, has been in poor case during recent years, and it remains for me now to add my small quota of the authority of facts.

CHAPTER III.

THE PROBLEMS PRESENTED.

IN his classical work on Heredity, Professor J. Arthur Thomson exhausts the evidence on Lamarckism available then (1908) in a manner worthy of the summing-up of an English judge. This is presented to the jury of the biological world and they are still considering it. Their verdict and his sentence are not yet delivered, and it may be they will still be long delayed. One might almost use the words of Professor Bateson, previously quoted, "on our present knowledge the matter is talked out."

I will make one prophecy in this volume and predict that the fourth edition of this work in 1930 will contain the verdict of the jury and sentence of the distinguished judge to the effect that in the case *Lamarck v. Weismann* the plaintiff has won. As in the Great War the Old Contemptibles held their line with the utmost difficulty against the disciplined hosts of the greatest army ever known till then, and yet the latter found their First Battle of the Marne, so perchance it may be in the present struggle.

I introduce this chapter with an important passage from the above work on the *Logical position of the Argument*, in which the two possible methods of establishing the affirmative position of Lamarck are given; these are, first, actual experimental proof of transmission, and, second, a collection of facts which cannot be interpreted without the hypothesis of modification inheritance. The words are:¹ "*The neo-Lamarckians have to show that the phenomena they adduce as illustrations of modification-inheritance cannot be interpreted as the results of selection operating on germinal variations. In order to do this to the satisfaction of the other side, the neo-Lamarckians must prove that the characters in question are outside the scope of natural selection, that they are non-utilitarian and not correlated with any useful characters—a manifestly difficult task. The neo-Darwinians, on the other hand, have to prove that the phenomena in question cannot be the results of modification-inheritance. And this is in most cases impossible.*"²

¹ *Heredity*, 1908, p. 240.

² I prefer to state the above passage rather than that on page 179, which is as follows: "The precise question is this: *Can a structural change in the body, induced by some change in use or disuse, or by a change in surrounding influence, affect the germ-cells in such a specific or representative way that the offspring will through its inheritance exhibit, even in a slight degree, the modification which the parent acquired?*" (Italics in original). The question is very precise and important, but I employ that given above in preference as lending itself better to the line of inquiry followed here.

I have placed this passage in italics because of its importance from the point of view of the two problems which I am presenting and would remark here that if only all the writers had used Professor Thomson's term "modifications" instead of "characters" in the statement of this doctrine much confusion and evasion of plain facts would have been avoided, and yet such workers as the Mendelians, if deprived of their clear-cut term "characters" would have been less able to carry on their studies. To this point of terminology I refer below.¹

¹ The term "character" derives both from its etymological origin and its application to biology a double-edged quality. This is of great value to the study of Mendelism which can only or mainly work with "unit-characters," and it also serves the Weismann dogma well. In both cases the term obliterates the conception of initial variation, and while serving the purposes of these two great schools of thought it directs attention away from the early minute and unimportant stages by which many germinal variations may have arisen. If it had been coined for the purpose, which it was not, it would have been a remarkable instance of polemic cunning. It will be evident in the course of this study of initial variation, that the accredited and general use of the term "character" begs the question far too manifestly for the general use of biologists. It be retained for the neo-Darwinian and Mendelian provinces there is nothing to say against it, but I adopt here with pleasure the alternative term, often used by Professor Thomson, "modification." This is wide enough to include the more clear-cut "character" so long as one makes it clear that the latter is one of the *germinal* variations. Further, I hold that his use of the term "transmission" instead of "inheritance" is the more useful for a wide range of phenomena. As far as possible I shall employ the expression "transmission of modifications," instead of that well-worn but often sophisticated expression "inheritance of acquired characters." This has been subjected by Sir Archdall Reid and Dr. Dixey, to say nothing of others such as Mr. George Sandeman, to a somewhat bewildering analysis. Thus the former says, "It follows that the so-called 'acquirements' are innate and 'inherited' in precisely the same manner as the so-called 'inborn characters.'*" Dr. Dixey admits "that all characters are both acquired and innate"*** and goes on to say that the accepted meaning of the terms was vague, that it led to confusion, and that it ought to be dropped. For this remark of Dr. Dixey one may be thankful, but of my friend Sir Archdall Reid I would ask what he is doing in this galley?

Sir E. Ray Lankester in a letter in *Nature*, 21st March, 1912, dissented from the mode of treatment of this point by Sir Archdall Reid and presumably also by Dr. Dixey in the words "It is not, I think, permissible to say that the normal characters which arise in response to normal conditions are with equal fitness to be described as 'acquired.'" As to what is a normal character and what are normal conditions there may be much reason for difference of opinion, but I have said enough of this discussion to show that the terms "acquired" and "character" would afford a biological Pascal some such food for criticism as did the term "probable" in his *Provincial Letters*. The less these two terms are employed the less misunderstanding there will be of certain problems.

It has been held that "discussing words is often indescribably tiresome, but it is better than misunderstanding them," which is most true.

* *Nature*, Vol. 77, Jan. 30th, 1908, p. 293.

** *Nature*, Vol. 77, Feb. 1908, p. 392.

In a world teeming with the life of plants and animals, and in the branch of science which seeks to interpret them, where we enter upon the unknown much sooner than in any other sphere of science, Weismann has set out to prove or maintain the most stupendous negative ever framed by the human mind. It would require generations of men to *prove* this negative, if it were probable, and his case rests mainly on the assumed weakness of his opponents. So what is needed and demanded from the neo-Lamarckians is the production of a few well-attested and verified facts, and, as he admits himself, then it must follow as the night the day that his followers will surrender his characteristic dogma. The more cautious leaders and teachers of the day say that this has not taken place and ask for facts, more facts and still more facts, and this attitude is both judicious and judicial, for example in a teacher so eminent as Professor J. Arthur Thomson. Scientific men, in such a position as he occupies with grace and distinction, owe a serious debt of loyalty to ultimate truth and to the inquiring minds of the young students of to-day and to-morrow. Those who are in a position of inferior responsibility and honour, and more freedom, just rank and file members of the Commons' House of Parliament, may be pardoned if they do not exhibit an excess of deference to authority and if they think for themselves.

Two Questions.

There are before the Scientific jury to-day two very vivid questions.

- (1) Can modifications in the structure of an individual organism, occurring as a result of its experience, be transmitted ?
- (2) What is the cause of variation ?

If, as Weismann taught, the answer to No. 1 is in the negative, there is little use here in trying to answer No. 2, for from the present point of view the two stand or fall together in the study of Initiative in Evolution. Such *distributional* answers to No. 2 as Bateson and de Vries may offer do not concern my purpose.

If No. 1 be answered in the affirmative it is sufficient for the purpose of treating initial variations from the Lamarckian standpoint, for it is hardly conceivable that Nature would neglect so simple and obvious a method of leading upwards and onwards the organisms that inhabit a changing world.

It is very clear from what is written on the subject of evolution to-day that a *point d'appui* in the process is earnestly desired by many workers and that Weismann's dogma stops the way. A very significant and important remark is made by Professor W. McDougall

in his small book on *Physiological Psychology*, with reference to the inheritance of acquired characters, that it is a "proposition which most biologists at the present time are inclined to deny because they cannot conceive how such transmission can be effected. Nevertheless the rejection of this view leaves us with insuperable difficulties when we attempt to account for the evolution of the nervous system, and there are no established facts with which it is incompatible."¹ I am aware that in the scheme of observed nature there is evidence of no iron necessity, that the convenience of psychologists should be provided for, and they, like others of us, have to do the best they can with the tools and the materials which exist, and I agree with Professor Thomson in his remark on *Misunderstanding No. 1*, "that our first business is to find out the facts of the case, careless whether it makes our interpretation of the history of life more or less difficult,"² but I am persuaded that he will not treat lightly *such* a statement, from *such* a source, on *such* a subject as that I have quoted from Professor McDougall. As to his second statement on the same page "that in the supply of terminal *variations*, whose transmissibility is unquestioned, there is ample raw material for evolution" it is important as an opinion, and no more, and there is in the present connection, an elusiveness about it which prevents one allowing it to pass. It should be noted that stress is laid upon the term "variations" and from the context this means congenital full-blown "characters" such as those that Weismann says are provided in the germ guided by selection. At any rate, initial modifications are not signified by Professor Thomson's remark. So for *evolution* of forms of life it is possible the assertion may be true, but apart from distribution of variations, under the process called amphimixis, some starting point is required for the initial and wholly useless stages of many variations. These may or may not become "characters" or adaptive.

What the Problems are not.

The ground may be cleared here by saying what our problems are not. There is no question as to whether Lamarckism or Darwinism represents the predominant partner in the story of life; there is no question of the "relative importance of natural selection and the Lamarckian factors in organic evolution," though such a question may arise when once Lamarckism has received its passport from the authorities; but the time is not yet. Nor is it a question as to the reason why adaptive modifications are so constantly

¹ *Physiological-Psychology*, 1911, p. 156.

² *Op. cit.*, p. 179.

present in the germ. It is not a question of Nature *or* Nurture, but perhaps may be found to be a study of Nature *and* Nurture. It is not a question of Mendelian analysis, nor as to the distribution of either mutations on the one hand, nor of minute fluctuating variations on the other. The problems are therefore limited in scope and ambition, and are none the worse for that, as being better open to correction or support.

The Problems Considered.

It seems but natural to most persons who contemplate with any care the ever-changing and progressive drama of life in plants and animals that unquestionably the *dramatis personæ* by their individual response to the environments and exercise of their functions must contribute a share, however small, to their offspring. When first this view presents itself to their minds they resent as "unnatural" any other possibility. But, alas! they find that such a conclusion is not permitted in those regions where alone the white light of science shines. Here the writ of *a priori* does not run. The spirit of inquiry makes its challenge to every pre-supposition and every assertion in its province—even those of current science. I have shown that this particular assumption of the natural man was firmly challenged by Weismann, who was not the first, but the greatest, biologist to teach that modifications are not transmitted. Accordingly, agreeable and convenient as it would be to assume the Lamarckian hypothesis as a working one, it needs in the present day to be supported by evidence before this can be allowed. Facts, then, against Weismann's dogma are demanded and of such a kind as will satisfy so powerful an advocate of his own views. In passing it may be remarked again that there is nothing so misleading as facts, except statistics, and for both sides to bear in mind the warning of a French writer that in such inquiries as this we should be careful lest we find the facts for which we are looking.

To meet the conditions laid down in Professor Thomson's Canon I propose to describe certain phenomena which are adduced as instances of modifications in certain mammals whose structure and mode of life are intimately known, and whose ancestry is little in dispute.¹ The most convincing of these lines of evidence are those which are shown to be outside the range of any form of selection, as well as the *distributional* factors of Mendel and

¹ With the exception perhaps of the highest of all, for since the publication of Prof. Woods Jones' *Arboreal Man* the question "Who is Man?" has received a new answer.

de Vries. It is well to enumerate here the six different factors in organic evolution which might claim a share in the production of such humble phenomena as form the subject-matter of this volume—they are :

1. Personal Selection of Darwin.
2. Sexual Selection.
3. Histonal or Cellular Selection of Roux.
4. Germinal Selection.
5. Inheritance according to Mendelian principles.
6. Inheritance of Mutations.

There is a somewhat severe and ill-defined condition attached to the formula in question for it demands that such modifications as will satisfy the neo-Darwinians shall not be *correlated with any useful character*.¹ If such a *conditio sine quâ non* were taken too literally it would at once foreclose the case as to the possibility of transmission of modifications at all, the questions of issue ought in that case never to have been raised—and, *cadit quæstio*. This cannot be the intention of the biologist who propounds the formula. It could not reasonably be carried so far as to insist that a modification arising from a certain habit, active or passive, in an animal, and which on that account, and on paper, may loosely be said to be 'correlated' with it, is to be ruled out. That would be tantamount to saying for example, that, because an animal must lie down in a certain attitude when it rests, or walk or run in a certain manner, in other words that it is useful to exist, certain modifications claimed to be due to these fundamental parts of existence must be excluded from the inquiry. The neo-Darwinian is not a critic easy to be entreated, but *that* he would not claim. Let me take one example of what I mean. A short-haired dog will spend a considerable part of its daily life, and presumably a long line of ancestors did so too, lying with its forelegs planted in front of its chest and its head either raised in the air when awake or resting on the upper surface of the forelegs (of course the familiar attitude of a dog with its body and head curled up and fore-legs doubled is not referred to here). If the hairy coat be examined over its neck and jaw, which lie in this attitude, on and against the forelegs, a remarkable reversal of the direction of the hairs is found and the outline of this forms an accurate mould of the surface applied to the forelegs. This is transmitted of course from previous generations of domestic dogs. A precisely analogous reversal of the hairs is found on the under or extensor surfaces of the forelegs, matching with wonderful

¹ My italics.

exactness the area of pressure of these on the ground, and anyone can see it who has a canine friend of the fox-terrier type. Long-haired dogs display it less neatly outlined. An instance such as this cannot be excluded from the evidence forthcoming because it is correlated with the useful "character" of lying in a certain attitude. Such a phenomenon, many similar to which will be seen later, had at any rate an origin *de novo* at *some time* in the ancestral stock, and in *some way*. To discover these is part of my business. The boldest neo-Darwinian will not claim that this arrangement of a dog's hair arose by selectional processes within the germ either in the initial or completed stages.

Correlation.

The term "correlation" is somewhat scornfully said by Weismann to be "unquestionably a fine word," and it has indeed in biological writings a very varied set of meanings. I will not vex the reader with a reference to our old friend Mesopotamia, but mention what Dr. Vernon in *Variation in Animals and Plants* says of the term, referring to the relation between stature and head-index in man: "Such a statement must vary according to the notion of the observer as to what does and what does not constitute correlation."¹ The most approved and precise meaning of the loose term in question is that associated with the work of the biometricians, and a few examples from Dr. Vernon's book will show how far this conception of correlation is removed from the literal application of Professor Thomson's formula. Dr. Vernon treats of such phenomena as the correlation of the long heads of greyhounds with length of legs, contrasting them with the shortened heads and legs of bull-dogs. He describes also the correlation in man between the stature and length of forearm from elbow to tip of middle finger, correlated measurements of crabs, of external structures of prawns, the tufts of Polish fowls correlated with perforations in the skull, also certain constitutional peculiarities with colour of skin. These few cases are enough to give an idea of the more precise and fairer acceptance of the term, but while these form a useful subject for minute study it may be remarked that they agree also with Lamarckian factors as to their origin and development. They are much more in line with Darwin's use of the word and are strangely reminiscent of the well-known example of the Irish elk with its great head and horns which was brought forward in favour of Lamarckism by Herbert Spencer. They

¹ p. 74.

breathe an atmosphere of physiology rather than anatomy, or function than form.

Enough has been said here by way of defining the terms of the issue. The negative we have to sustain is that the following facts and observations declare that certain small modifications cannot be governed by selection and are not correlated with useful characters. It will be shown later that Professor Thomson's stringent condition is not in all of them complied with, but that, in spite of this, the probability of their being valid examples of Lamarckism in practice is immense.

CHAPTER IV.

INITIAL VARIATIONS AND TOTAL EXPERIENCE.

THE present chapter is on *a priori* lines and will perhaps be dismissed with a wave of the hand or hurriedly skimmed over, but I pray the reader at least to read the two or three last pages of it. It is at any rate suggestive, and perhaps I may anticipate the comments of the neo-Darwinian and throw myself on his mercy by mentioning a remark of the late Sir Andrew Clark, prince of physicians and genial cynic, which he made to a patient in my presence. A lady not distinguished for depth of thought asked him a rather silly question in medicine. As if offended he drew himself up, holding in his hand a cup of tea which he was enjoying, and replied at once "Madam, you must get a younger and more inexperienced man than I am to answer you that question."

A very high degree of probability may be attached to the presupposition that Lamarekian factors, even in their humblest form, may enter into the story of the organisms as historical and living beings. Every hypothesis in matters of science, or, to put it at its lowest, every scientific guess must transcend the evidence at the time available.

Total Experience.

The suggestion I venture to make here is that if we take a comprehensive view of certain two great groups of phenomena in nature, which may be termed universal in their extent, it is difficult to conceive that they are not causally connected in the sense that one is the universal antecedent of the other. On the one hand are found universal minute differences, not only between any pair of organisms, but of any two corresponding parts of any organism, even to the size and shape of each leaf on each plant. On the other is universal discontinuity of *total experience* of all organisms. This term includes all the stimuli of use and environment to which an organism is exposed throughout its whole existence, and its response to them. It includes the whole succession of active and passive stimuli which begin with the formation of a zygote in higher forms, for example, and continue till the death or end of reproductive life of the individual. It stands for such stimuli as arise from

habitat on or in the earth, in various levels of salt or fresh water, in sea, lake, pool and river, and in the branches of trees, from *climate*, from degrees of *light*, *temperature*, *moisture* and *wind*, from presence and activity of *enemies* and *rivals*, from *supplies of food*, from *geographical* and *topographical* position. Such an enumeration of stimuli might be much extended if it would serve any purpose. But it is enough to say that the number of such stimuli, and the varying degrees in which these are received and responded to, have hardly any limit which we can conceive. It is a very different and harder task to find out the proportion in which such stimuli are advantageous, injurious or indifferent to the organisms, but it may be taken as certain that the vast majority are indifferent in the sense of producing structural change, and, that the advantageous stimuli transmit structural effects to offspring, is only a matter of very strong probability. If the above two groups of phenomena are not causally connected they are intertwined with remarkable closeness and perversity. This aspect of the "web of life" has received attention, and deserves more.

Discontinuous Environments.

Some reference must be made here to observations of Prof. Bateson in his work on variation. In the first place he makes a most valuable statement that *the environment as the directing cause is essential to Lamarck's theory and as the limiting cause is essential to the doctrine of Natural Selection*"¹ (which I venture to place in italics on account of its importance to all who seek the pathway of organic evolution) and points out also that "diversity of environment is thus the measure of diversity of specific form. Here then we meet the difficulty that diverse environments often shade into each other insensibly and form a continuous series."² This is clearly true and important to the subjects he is discussing. But in regard to the conception with which I am here concerned, that of *total experience* of organisms, it must be remembered that there is no such thing as an environment apart from the living beings that it environs, and that from this point of view there is no such thing in the world of nature as a continuous environment. The environment of two amœbæ living under a cover-glass is, for them, far from continuous. In their infinitesimal existence the exact position they occupy in the enviroing drop of fluid, in which the proportion of their humble fare at one side of the cover-glass

¹ *Op. cit.* p. 6.

² p. 5.

is not the same as that on the opposite side, renders their environments discontinuous, or different from that of another amœba occupying a position and "environment" which *we* should consider identical. And this consideration applies to the other few "tropisms" which enter into their little lives. This statement may be difficult to prove, but it is a necessity of thought. An illustration may assist one in visualising such discontinuity. A fly is seen crawling at its own pace up one of the great pillars of St. Paul's Cathedral. It comes to one of the thin layers of cement worn down with age and so delicate that a man can just see it in a good light. The fly pauses, and passes into what is for it a chasm, with as much relative deliberation as the man would show in passing across a deep railway cutting. The number of pictures that could be made of cases corresponding to that of the amœba is incalculable. A few will suffice. Two plants of the common nettle are growing on the south side of a ditch in a lane, one rooted a foot higher than the other. The upper one receives throughout its life from wind and sun stimuli slightly different from those received by the lower, and from the soil slightly less moisture. These again receive stimuli very different from another pair on the northern side of the lane. Again in windy weather a clump of sycamores facing the south-west in England, and situated on the ridge of an eminence, will receive very different stimuli from a similar clump on the north-eastern slope of this eminence, and will demonstrate the fact, as to force of wind, by a marked slope to the North East. Even in either of the clumps the individual trees present varying degrees of slope according to their position. The total experience of these two clumps of sycamores and of any two in each clump is obviously different. In a windy situation you can tell in July which is the prevailing wind by noting the main inclination of the ears of corn in a field. Again two male sticklebacks in a pond will make nests for the eggs, there to be deposited, and one will choose a spot on the southern and another on the northern side of a little promontory of soil and stones at the edge of the pond. One will find ready for him materials for building his nest different from those of his rival, and he and his wife and family will receive for that season very different stimuli, and so will the stimuli differ in other phases of their existence in a pond occupying a few square yards. On a sandy bank in a garden facing south you may discover two little caves ingeniously hidden by a small opening, and in each of them you can see a toad. Though these are only a few feet apart one is more widely open to sun and wind than the other and one deeper than the other, and whatever the other activities of the

two toads may be in their little shelters, they receive stimuli different in strength and number. On another bank in the same garden less exposed to view, and altogether more sheltered from sun and wind and enemies, a robin has built a well-hidden nest. If the six fledglings in the nest are watched when the mother is absent they are seen to occupy very different positions of comfort, pressure and warmth. When the mother-bird returns from marketing she is hardly impartial in the amount of food she puts into their open beaks. But the slight and perhaps unimportant inequality of their experiences as fledglings is nothing to that which follows when they fly abroad, and which continues to the end of their lives, the life of a robin being somewhere about ten years long. The differences of the *total experience* of the six young robins is easy to picture. Again, surely, the total experience of two fleas on the body of one plague-rat must be for such small creatures of importance to their welfare, according as their respective "itches" are on the abdomen, back or legs of the host. When the life-history of a human being is told in full the discontinuity of his total experience needs no proof. The proof is written large before our eyes. But, perhaps, one example may be given. There are two very eminent living writers, whose light has certainly for some years not been hidden under a bushel, Mr. Chesterton and Mr. George Bernard Shaw. We may be said to know them well. Leaving out of sight the Celtic strain claimed by one, and indeed all inherited differences, we see two men of perhaps equal ability, near of an age, both living in London, both living by their pen, both in easy circumstances. When one considers for a moment the different company these two men keep, their different and opposing outlook on life, their different and opposing forms of diet for their minds and bodies (I know which of the two diets of those men I would choose and with which of them I would prefer to be cast on a desert island) one can only say that the total experience of Mr. Chesterton differs from that of Mr. Shaw as cheese from chalk, which things, incidentally, are an allegory in the philosophy of life.

The thought here briefly expressed falls well into line with Prof. Bateson's statement that the directing cause of the environment is essential to the theory of Lamarck, and I do not hesitate to add to it the assertion that *all environment*, in the wide sense of total experience, is *discontinuous*. There are no such phenomena in total experience as unit-characters of allied forms, small variations are the rule. Without doubt a large proportion of the stimuli received by an organism are as figures written on a slate and at once wiped off. They are as the snows of yester year. The most they

do is to contribute in their measure to the metabolism of the organism, being too numerous and minute to affect any structural change. In a higher form of life none but those which are frequently repeated in the individual and in succeeding generations can effect any structural response.

Mould and Sieve.

It will be remembered that a single example was given of a short-haired dog in which its common habit of lying was associated with a certain pattern of hair. This introduces and illustrates the very wide conception of a moulding process undergone by an organism. It is one familiar to biologists and very much so to Professor Thomson in his various writings. Not less is he an exponent of the metaphorical work of the sieve of natural selection. I therefore claim nothing new when, with the temerity of certain persons treading where others are said to fear to do so, I invent an inclusive term and propose to call the two fundamental factors of organic evolution *Plasto-diathesis*¹ in which the conceptions of mould and sieve are included and hyphenated. This word is no more proposed for its elegance than are *panmixia*, *amphimixis* and *tetraplasty*, though perhaps it may be the etymological superior of one or more of these. It is at any rate inclusive and perhaps sufficiently audacious to assure the inventor of the title of Dr. Pangloss of controversial memory. But as hard words break no bones I have taken this risk and it would appear to be a convenient "conceptual counter" and even Professor Karl Pearson could not consistently forbid it. It has at any rate the merit of having a meaning clear to all friends and opponents alike of Lamarckism. It will be observed that the two words are placed in what I take to be their natural order as expressive of the Alpha and Omega of the story of organic evolution. The moulding process is claimed to precede that of the sieve, as physiology precedes anatomy and function structure, in that form of biological speculation which is held here to be the soundest.²

¹ From the Greek. { *Πλαστος* from verb *πλαττειν* to mould.
διηθειν to strain through.

² The twin metaphor here chosen for the name of a complex natural process should be cleared a little of a certain obscurity of meaning. A mould is familiar to all in domestic and industrial matters, but there are two sides to the metaphorical conception. A plastic object may be moulded by the hand of man as in his ruder, but more laborious days, or it may be pressed into an artificial mould that he has made by means of his hands and tools. One of these we know in the rude pottery made by prehistoric man and the vessel of the potter described by Jeremiah the prophet. We know also those machine-made moulds, so accurate as to be fitted for the coinage of a nation

So the banns between Lamarck and Darwin are published, not for the first time of asking, and who shall say that there is cause or just impediment why these two should not be joined together in holy matrimony?

I conclude this chapter with a passage from the life of Columbus by Washington Irving which affords a fitting parallel from history in the higher development and union of two formerly hostile Kingdoms, and the moral of it is clear and simple. But as a forensic junior I beg to enter a *caveat* to the effect that though the name of Columbus occurs no suggestion is made of the discovery of a New World.

"It has been well observed of Ferdinand and Isabella that they lived together not like man and wife whose estates are in common, under the orders of the husband, but like two monarchs strictly allied. They had separate claims to sovereignty in virtue of their separate Kingdoms, and held separate councils. Yet they were so happily united by common views, common interests, and a great deference for each other, that this double administration never prevented a unity of purpose and action. All acts of sovereignty were executed in both their names; all public writings subscribed with both their signatures; their likenesses were stamped together on the public coin, and the royal seal displayed the united arms of Castile and Aragon."

and able to puzzle a clever coiner who tries to copy them. We know the rough hewing of the stone by the sculptor which follows his moulding of the clay. And in Sacred Writ we read of a double process when the Hebrews not content with their object of worship took the golden ear-rings of their women and Aaron "received them at their hand and fashioned it with a graving tool, after he had made it a *molten calf*." But as no conception of a mould in biological matters, which connotes the rigid accuracy of the coiner's mould, can represent the truth, the rougher and freer meaning of the term is here employed. A similar double meaning is implicit in the metaphor of the sieve, considered as a human utensil. I believe we owe this idea of a sieve to Professor Thomson, but am not sure on this point. But I have not been able to find any definition as to the way in which the sieve of natural selection is held to act. A sieve is of course for sifting substances, and the size of the mesh is adapted by us for the purpose we have in view. We may want a sieve to hold back for us the fit or good and allow the unfit or bad to pass through, for example wheat and chaff, or we may employ it to separate sand for our purposes from fine gravel. The former is of course the most common of the purposes for which a sieve is used. So here the comparison of personal selection with the action of a sieve agrees with this aspect of a sieve, the fit being retained and the unfit allowed to pass through, thus agreeing with that view of Spencer's of the survival of the fittest which is held by most authorities to be more accurate than Darwin's Natural Selection.

CHAPTER V.

METHOD OF PROOF.

IN a matter of scientific inquiry one cannot go far wrong if one follows the advice of Henri Poincaré, who lays down certain principles of method ; four of these are the following :—

- (1) The most interesting facts are those which can be used several times, those which have a chance of recurring.
- (2) The facts which have a chance of recurring are simple facts.
- (3) Method is the selection of facts, and accordingly our first care must be to devise a method.
- (4) We should look for the cases in which the rule established stands the best chance of being found fault with.

The groups of facts described in the succeeding chapters are in agreement with these principles in the main, and are perhaps like a dust heap for their intrinsic value. But one knows that before now among a good deal of *débris* a rusty key has been found which has opened a cabinet containing certain treasures, and in the hands of someone else than the finder has produced useful results.

The headings of the chapters describe the facts, and there is no need to enumerate them here. The first and largest group is studied according to a method which is in a measure applied to all the others. Most of them are external or superficial phenomena and accordingly are open to others beside the expert for observation and corroboration, or the reverse. The typical plan adopted is as follows : a large number of related phenomena are chosen, and the more prominent of these are observed and described. Keeping in mind the two plain issues laid down, the origin of initial modifications and their transmission, I have selected the facts because, especially such as those of the hair, they are very simple, of wide distribution in animals well known to us, such as the domestic horse and man, and none are brought forward which any other observer cannot study for himself if he has some anatomical and physiological knowledge, some training and care in recording observations. In most centres of population there are still left a good supply of horses in streets and stables, of preserved specimens in museums and living ones in zoological gardens, and of hairy young men who

will hardly refuse a polite request to examine the minute hairs clothing their trunks and limbs. One has to pursue a certain amount of that study which may be called the sister of plant-ecology, that is, animal-ecology or the behaviour of animals at home. The student of these matters, it may be freely admitted, will complain, unless he has some hypothesis or line of thought to follow, that he has been set down in a valley in which the bones are very many and very dry. But, armed or primed with an hypothesis, he may find an affirmative answer to his question "Can these bones live?" Every group of natural phenomena, *without exception*, has some meaning for those who will interpret nature rather than bully and slight her, and whatever anointed king may claim sovereignty over it the humble fact cannot be denied that "whatever phenomenon is, *is*."¹ Again I would refer to Howes' inspiring note: "We live by ideas; we advance by a knowledge of the facts; content to discover the meaning of phenomena, since the nature of things will be for ever beyond our grasp."² The facts adduced are simple, have a chance of recurring and are widely distributed among multicellular animals—the botanists and plants can very well take care of themselves. I must once more state that I am attaching to the considered facts a value of a somewhat unusual kind—their *intrinsic unimportance*. For anyone who has had to encounter the skilful dialectics and counter-attacks of a well-equipped neo-Darwinian it is well that he should remember the maxim of Napoleon, "Be vulnerable nowhere." It is necessary to show evidence for Lamarckian factors in which no degree of selective value, survival-value, can be seen by hostile sharp-shooter while he works in his trench. The main line of defence, or more correctly what Hindenburg would call "offensive-defence," is therefore made to rest on the phenomena of hair-direction, which, I submit, are impregnable to the forces of selection, probably in all the hairy mammals, but certainly in that hairy animal called Man.

Thesis.

If these groups of phenomena were being studied apart from the hypothesis they support, a much more full treatment of all of them would be required, such as I have given to those of hair-direction in a book published in 1903 on *Direction of Hair in Animals and Man*. The limited thesis, however, here upheld is that the phenomena are produced by the factors of stimuli and response in

¹ Jevons.

² British Association of Science 1902. Zoological Section.

the course of the total experience of the organism, that the essence of the matter is the production of initial modifications, that instances of these in well-known animals are produced before our eyes by ascertainable mechanical stimuli, and that, especially in those of hair-direction, experiment is adduced in proof of the thesis that some modifications are transmitted.

Procedure.

The order of proceedings may be tabulated thus :—

- (1) Observation of selected facts.
- (2) Evidence that certain of these are produced in the lifetime of the individual.
- (3) Evidence that among the facts of direction of hair and others there is to be seen an orderly evolution rather than a casual appearance of the changes noted.
- (4) An hypothesis as to their production.
- (5) Exclusion of selection as a possible cause of these, and of correlation as properly understood.
- (6) Experiment in verification of the Lamarckian interpretation of the phenomena.

And here, before I hear some Prince Henry of the genus Weismann, Mendel or Gallio groan aloud : "This intolerable amount of sack," I proceed to offer him a few loaves of home-made bread.

CHAPTER VI.

EVIDENCE FROM ARRANGEMENT OF HAIR.

Ex Uno Disce Omnes.

THE singular arrangement of hair on the forearm of man is the subject of some curious statements by Darwin, Wallace and Romanes, and these suggested to me twenty years ago the following line of thought. To many minds the text will appear a humble one, but it opens many avenues of inquiry.

These three illustrious men are all more or less inaccurate and incomplete in their descriptions of the hair on man's forearm, though Romanes¹ gives a drawing which supplements his written account. They looked upon it as a vestige of the pattern of hair on the forearm of existing anthropoid apes, especially the orang, in whom its fully-developed form was an adaptation governed by Natural Selection. Of the three, Wallace is the most uncompromising on behalf of this view, Romanes rather accepts it *en passant*, and Darwin in a long passage² adopts it with some reserve and his usual respect for the work of his great co-worker, as the most probable explanation of a fact which lay heavy on his scientific conscience. Indeed, for all these great men it was a *crux*, though Romanes, with his Lamarckian views, need not have found much difficulty with an alternative account of it.³

At the time when these statements were made, the lineal ancestors of man were much more definite personages than they are now, as Arthur, the legendary Celtic hero, was formerly held to be an historical personage more than is the case now. These ancestors were generally believed then to be found among the four existing anthropoid apes. The picture of our ancestor among

¹ *Darwin and after Darwin*, Vol. 1, p. 90.

² *The Descent of Man*, Chap. VI., p. 151.

³ I may remark that Darwin seems at an earlier date to have made a very curious suggestion in this connection, for Hartmann, in his work on Anthropoid Apes, p. 99, quotes him as saying: "We should, however, bear in mind that the attitude of an animal may perhaps be in part determined by the direction of the hair; and not the direction of the hair by the attitude," a notion so obviously untenable that it does not appear in the second edition of *The Descent of Man*, 1896.

the apes, as given by Wallace, in connection with this state of the hair on his forearm, represents him as spending much of his time like the gorilla, who, according to Livingstone, "sits in pelting rain with his hands over his head." He would no doubt find the thatch-like arrangement of the hair a tolerably efficient umbrella, but one may doubt very much if so clever a denizen of the tropics would fail to find under the great branches of trees, in a tropical forest, a better covering and one more like the roofs of our houses. But when we cannot find a roof to our heads we—and the orang or gorilla—naturally employ a substitute, and not otherwise. Be that as it may, it is doubtful if the thatch of his forearms would supply him with that survival value on which the theory of Selection depends, to say nothing of the fact that in its incipient stage the reversal of the slope of hair, inherited from the lemur stock, would be trivial and useless.

But one must ask: "Did man's Simian ancestor really loaf away so much of his time in this dull manner? and was the running-off of rain so frequent and imperative a need as to make him set to work to invent this special adaptation?"

After some millions of years have passed since his day we are not in a position to go beyond speculations, and this one seems barely credible, moreover, it is quite unnecessary, as certain following facts will show.

Steps of the Inquiry.

Having expounded the text and its context, I would mention that in 1897 I came across these views of biologists as to the very strange arrangement of hair on man's forearm, and was struck with the inadequacy of the theory of Darwin, Wallace and Romanes to account for the state of things which every man can find, if he looks for it, on his own forearm. I examined a large number of apes and monkeys so as to test the theory, and the results were published in *Nature*, Vol. 55, under the title "Certain vestigial characters in Man." Suffice it to say that from the evidence I brought forward one had to choose between two heresies: either to deny the Simian ancestry of man or to affirm the inheritance of some acquired characters; and I chose the latter. The choice of "evils" or heresies which had to be made then will serve as an introduction to all that follows.

This article was followed by a paper at the Zoological Society of London on "The Hair-Slope in certain Typical Mammals," and after this came a paper at the same Society, giving evidence and reason why certain patterns of hair in some mammals should rank

as specific characters. Various other papers at the Anatomical Society of Great Britain and Ireland were read and published and others at the Zoological Society, in which different regions of the hairy coat of man and lower mammals were dealt with. In 1903 the whole subject of the Direction of Hair in Animals and Man was treated in a book freely illustrated.

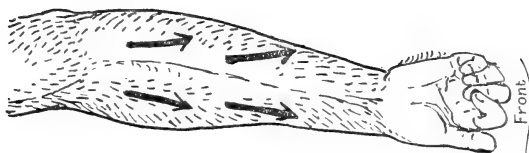
I then followed the advice of Horace and left the subject alone for nine years, during which time my further observations and reflections served but to confirm, except in two or three unimportant details, the results and conclusions in the book and papers of an earlier date. The connection between the habits of an animal and the distribution of its hairy coat were always cropping up, and I saw then and see now no possible explanation of the connection than that the former is the efficient cause of the latter.

How the Hair is Arranged on the Forearm.

Returning now to the text, the remarkable arrangement of hair on man's forearm, attention may be directed to the accompanying figure of the forearm of a lemur, an ape and man, in which the extensor or back view of this limb-segment is shown, the heavy "war-arrows" being employed to direct the attention of the reader to the main lines in which the hair-streams flow. The front or flexor surfaces in the lemur and ape are not shown because they are precisely like the corresponding back surfaces, and the flexor surface in man is shown in the figure. The figures are so much like diagrams that a very little detailed description will suffice. For the examination of the hair on man's forearm the best subject is a dark-haired youth, and it is easily traced, though in any hairy subject it can be shown up well by placing the forearm in water for a minute and allowing the water to drain off. The normal and congenital hair-slope on the forearm is then well displayed.

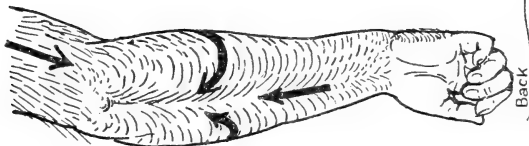
On the front surface of man's forearm the hairs point away from the elbow and divide in the middle of the surface into two streams, one passing to the outer and the other to the inner border in a downward gentle curve, and they join the streams of hair on the back surface. In this pattern there is nothing very peculiar, for it is shared by many monkeys.

When the back surface is examined it is found to present an arrangement of the hair which is *unique* among hairy mammals. The figure shows the eccentric course taken by the hair on the back surface. In the centre, exactly along the extensor border of the ulna, from the wrist to the point of the elbow, the hair-stream



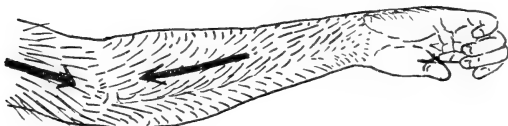
Front

Man



Back

Chimpanzee



Lemur

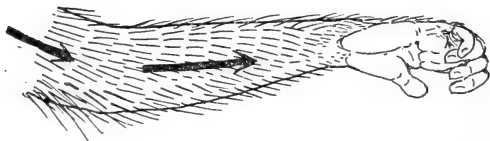


Fig 1.—ARRANGEMENT OF HAIR ON THE FOREARM.

has been bold enough to turn straight *upwards* in a narrow line, and it was here that our three great leaders saw their chance of claiming for Selection a tiny bit of territory, a kind of Duchy of Luxembourg between two great States, though, as I proceed to show, the claim is disallowed and untenable.

In the ape the hairs of the forearm are much longer and thicker than those of man, and both on the front and back all point *from the wrist to the elbow*.

In the lemur all the hairs point *from the elbow to the wrist*.

In the products of Nature there are no freaks, or impish tricks performed, and it is not for nothing she does her work. Every one of them asks for and should receive an explanation consistent with fact and reason, and here comes in the need for studying, as one may, the broad outlines of man's ancestry. His ancestor being now sought in an earlier and more generalized stock than that of the four genera of anthropoid apes known to us, the most instructive and safest line to take is to trace him back to the stock lemur, who remains to-day among the most Chinese or unchanging of known mammals. In his illuminating work, *Prehistoric Man and History*, Professor Scott Elliott adopts an excellent term, "lemur-monkey-man," to sum up, without missing links, the long ancestry of man. I take the liberty of adapting this term more closely to the present inquiry and use that of *lemur-ape-man* instead, for whatever may be the relation of man to present apes some ape-like ancestors enter into his genealogical tree.¹ For my purpose the monkey is less useful because his hair-slope differs so little from that of lemurs, whereas apes have made for themselves a very remarkable position as regards the hair of their forearms. Our series of animals for study is then well represented by the lemur-ape-man—hypothetical, necessary and serviceable. Through all the immense stretch of time occupied in this process of descent there has been ample opportunity for the lemur to change his fashion to that of the ape, and the latter to change to the present fashion of man.

This simple arrangement of the lemur's hair is common to that of all the more primitive long-bodied mammals, of which an otter is a good example, and I venture, greatly daring, to call this the normal slope of hair. Somewhere and somehow in the human tree there has appeared a total reversal of the lemur-type; the stock of apes acquired a new fashion, and gradually discarded

¹ This was written before the publication of Professor Woods-Jones' book *Arboreal Man*.

altogether their ancient inheritance, beginning their innovation perhaps, with *Dryopithecus fontani* in the Miocene Age.

The Dynamics of Hair-Pattern.

There are a few well-known facts which it is necessary to bear in mind if one is endeavouring to understand the mode of origin and order of the events before us. The hairy coat of a mammal is composed of individual hairs of varying length, colour and thickness, each being rooted in a tiny pit in the skin and growing from a papilla at its base. As the hair grows, its free end is pushed away from the papilla at the rate of one inch in two months. This is the rate in man's hair, and it is probably greater in the case of lower mammals on account of the greater importance and physiological activity of their hairy coat than in man's. But one inch in two months is a close enough calculation. Here, then, is a structure which grows throughout the whole life of the animal, and has to dispose itself somehow on the surface of the skin. It does this *in the line of least resistance*, and to trace this line is the Alpha and Omega of the present inquiry.

There is a conception of much value in understanding the dynamics of the distribution of hair, and that is to view the hair of mammals as composed of certain streams. As in every illustration, this conception may be challenged because of some difference the critic may find between these streams and a stream of fluid. It certainly does not leave its bed as do the component parts of a river, a glacier or molten lava, for the base of the hair is fixed. But it will serve, and is at least not more open to objection than certain useful metaphors in biology as when the genealogy of man and animals is pictured as a tree, or the living things of the earth as a "web of life." It is, then, as *streams moving at the rate of one inch in two months in the lines of least resistance* that I propose to discuss the animal hair and its diverse patterns and offer no further apology for doing so. Just as in the cases of a stream of water with varying banks and rocks in its course, or a glacier with its mountain-sides and sinuous valleys, or a stream of lava with small projecting surfaces of a mountain, our stream of hair flows on, hindered only by adequate obstructions.

Yet another conception from the region of metaphor must be mentioned. It is one which will commend itself to every mind which has been steeped in thoughts of warfare for five years. We are all soldiers now; we think in terms of military affairs. In the case of our hair-streams there are in many regions two forces directly opposed to one another, others in which no struggle has

yet occurred, as, in the Great War, Italy was not at one period at open war with Germany.

Between the opposing forces in our small battle-field of the hairy coat there have been waged battles to which those of Mukden, Verdun, the Somme and Arras, are not to be compared in point of time. They are but as one day to a thousand years. On one side of the conflict in our present chosen field the ancient primitive type of the lemur has remained entrenched for some millions of years, until there arose new forces in its descendants on the other side and this changed the war of positions into one of movement. It was indeed "a contemptible little army" which came forward to oppose the ancient barbarian forces of the lemur, long prepared and organised, and these new armies fought under the banner, Habit. In the slowly-formed patterns in many types of mammals we have records of the treaties made after these long struggles and the rectifications of frontier which became necessary. The critic may call these "battles of kites and crows," and ask What war correspondents were allowed to describe them; but a battle, whether great or small, long or short, is important to the parties concerned, and it is open to us to "reconstruct" the facts of the battle as do the historians on their part, for example, Sir James Ramsay the battle of Agincourt—with tolerable verisimilitude. But in science, especially geological science, the process of reconstruction is much more ambitious and bold than any that is here attempted. Who has not been fascinated, if he has read Sir E. Ray Lankester's work on Extinct Animals, by the skill and daring with which he conveys to us a vivid idea of the form and mode of life, with scanty data, of the extinct Moa of New Zealand, the great Pterodactyle, Pteranodon, or the Diprotodon of Owen—"the probable appearance in life" of these uncanny but very real inhabitants of the earth in days long past. How skilfully did Owen from a piece of bone seven inches long, sent to him by a gentleman in New Zealand sixty years ago, pronounce it to be a part of the thigh-bone of a bird like an ostrich, and then after a few years had passed, confirmed it by more bones of the skeleton, till the large Moa, extinguished 600 or 700 years ago by the Maoris, lived again before us—an historical personage; or how by the examination of the skull and most of its skeleton the giant marsupial from Australia, Diprotodon, was resuscitated and admired; or again, how from the bones of the arms, shoulder-girdle and fingers was built up the strange body of Pteranodon, the great flying dragon. All of which is the legitimate and approved business of biologists and palæontologists, and this digression is made here to show that my line of

treatment of a little subject agrees with that in a greater one ; nay, it even proceeds in its explanations of events on the ever valuable principle of Lyell in a still greater one without which to-day geology would be a thing of naught, that is, the principle of *explaining changes in the surface of the earth by reference to causes now in action*. The objection that one subject is very great and the other very small is not valid ; for one as much as the other there are millions of years to be had for the asking. Who in these days hesitates to talk and try to think in millions ?—tens of millions of men, millions of soldiers, millions upon millions of money, millions of bacteria in vaccines and millions of money belonging to other people disposed of by the new spendthrift Minister ?

From Lemur to Ape.

Returning now to our Eocene lemur we must remind ourselves of the problem before his simple mind and those of his Simian descendants. How was he to change so greatly the direction of the hair on his forearm (Fig. 1) till it should turn right about face and imitate those great German “victories” of Hindenburg, well called Marshal Rückwärts ? The problem lies open in the Figure and receiving no aid from Selection or survival of the fittest, in this little effort, he had to fall back on the eternal and tedious force of habit and use. I am afraid if here I were interrupted by some critic, more learned than wise, by a summary demand on the part of Selection for its share in the result, I should be tempted to reply with the word *Φλυαρία* employed by George Borrow, forbearing to give the translation of the reply as he gives it. Anyhow, it is a case in which to “listen politely and change the subject.”

Here comes in the aspect of strife between primitive and new obstructing forces in a little hair-stream. The lemur lives in trees and carries on a stealthy nocturnal business, moving on all fours in quest of his daily bread, and no external force or new habit avails to modify the hair-slope on his forearms, and so it remains until some primitive form of monkey, gradually evolving into a primitive ape, brings into the family new habits and customs. Other men and other manners appear in the Miocene Age. Our supposed *Dryopithecus fontani* becomes more upright in his bodily, and perhaps his moral habits, and spends an increasing amount of his leisure time in the sitting posture ; his hands are frequently grasping a bough as he sits and reflects, it may be in a man-ward direction, or, as is more likely, on his last meal of nuts and fruits. But he did not spend quite so much time as Wallace and others think in this futile attitude, for he knew in his way as much as the modern

bachelor does, of making his posture comfortable and restful when he was not out at work, and he varied his plans by resting his forearms on his thigh, crouched up and cosy, and doubtless slept much in this attitude. All these bold departures from his lemur-ancestor's habits had the necessary result of altering the slope of his hair on the forearms, which was now growing as long and coarse as we see it to-day in the orang. In course of milleniums the ancient forces yielded to those of the new armies, and the once normal slope became reversed in a way which shocked the conservative lemurs of his day. It requires little imagination to see how the lengthening thickening hairs on this limb-segment became changed in their direction by friction against the opposing surfaces of the thighs, by gravitation, and the frequent dripping of rain when they were held up to grasp a bough. Here then we see at work new forces of friction, pressure, gravitation and dripping of rain, turning endlessly and slowly the lemur-fashion into the ape-fashion, with unlimited time for their effectual action. In this stock of Man's ancestry Selection was taking care of the individual and Habit of the details of his making—two truly harmonious partners.

From Ape to Man.

Another step, and a long one, has still to be taken from the ape-fashion to that of man. Bearing in mind that the lemur-fashion has been totally reversed by the ape it startles one to find that man in his modern fashion has largely reverted to that of the lemur on the front and sides of his forearm. This is clearly shown in Figure 1. There also you see graphically recorded in the hair of the extensor border of the ulna, a little *backward* streak, a poor little legacy of fifty pounds from the fortunes of many thousands once possessed by the ape. From the present limited point of view, man is a veritable pauper, and his possessions in this limb-segment may with some irony well be called a "vestige."

Professor Scott-Elliott in his book, *Prehistoric Man and His Story*, p. 60, goes rather wide of the mark here in his graphic picture of our rude ancestor and his hard life. He gives too strongly the idea of him sitting asleep in raging gales, in driving rain which is neatly conducted by the thatch of his hair off his skin. As far as it goes this need not be questioned, as a matter of probability, but he states far too broadly "The hair on the arm, even of those civilised men who retain sufficient to trace the arrangement, turns *down* both upper and forearm to the elbow"¹—true as to the

¹ *Prehistoric Man and His Story*, p. 60

upper arm, but only true of the forearm in a very narrow streak of hair over the extensor surface of the ulna. The fact is that in every human being, not too old, its course can be traced with a lens. He overlooks also from this protective point of view the fact that the ape or early man, in the position of rest he describes, would have very much the reverse of protection from the "lie" of the hair on his thighs, for this is towards the knee and is well calculated to catch the rain and conduct it carefully, or let it run, into his groins. So the protection theory (under the empire of Selection) is again in straits. But I must not forget my self-denying ordinance alluded to in the Preface, but will show how the ape fashion began to be modified into its present and probably final form in man. Still further changes in the simple habits of the earliest men became frequent, and fresh forces were organised in our mimic battlefield. Gravitation gradually ceased to act as the hairs became thinner and shorter. Friction and pressure changed their lines of incidence with the increasing tendency of man to assume the upright posture, for the surfaces exposed to pressure and friction were only affected when the extensor surface or back of the forearm rested on some supporting object, an attitude extremely common in man as we know him now. Then came the opportunity of the primitive barbarian host, the lemur fashion, by a prolonged counter-attack to recover on the greater part of the forearm the ground lost millions of years before by the ape, and then was engraved on the forearm of man the permanent treaty which we have before us to-day.

This small and apparently trivial battle-ground has been described at what may seem undue length, but it is a miniature of the rise and fall of little empires such as here engage our attention, and I make no apology for this to the reader who has gone thus far with me, for, on the principle of *ex uno disce omnes*, all that follows in other areas of the hairy coat of mammals will be the clearer, and little repetition will be needed.

NOTE.—Two terms have been used somewhat freely in this Introduction, "vestige" and "normal," and a few remarks upon them are not out of place, for they are both somewhat ambiguous and apt to be carelessly employed.

A vestige in biological writings is almost the exclusive property of the Pan-Selectionists, and no one can doubt that on the one hand it is a far more correct term than that of rudiment which Darwin employed so freely, on the other that they have a perfectly legitimate claim to it in a large number of obsolete structures of animal forms. But vestiges, footsteps, footprints, have another and equally correct meaning, even if less often thus employed, in the fact that a vestige or footprint may just as well be a relic of what the race and individuals have *done*, as a relic of what they have *retained* in the way of possession, and I submit that the facts and arguments I have here advanced afford a valid claim to the term "vestige" in the results of certain *doings* on the part of animals—as will appear later still more clearly.

The term "normal" is a fine field for dialectics, but neither ordinary men nor scientific students can do their work without its use, and yet it would have been an intellectual treat to have heard how Huxley, for example, would have turned inside out any opponent who chose to employ it to his dissatisfaction. In a strictly-conducted tournament no evolutionary biologist would allow its use—to his adversary. A norm for him exists only as one of Professor Karl Pearson's "conceptual counters," a piece of mental shorthand or hardly more than a *pis aller*. Among the fundamental conceptions of organic evolution there is one which is almost a truism, the doctrine of Heraclitus, πάντα ρεῖ, the everlasting flux and change of Nature and her products. In strict logic, according to what we all now believe, there is no possible norm. All that one may do is to take stock at a certain epoch of evolution and label, for our own convenience, some group, or organism or structure as "normal"—and go on with our business, collecting some specimens, calling them type-specimens, and putting them in books or cases in the Natural History Museum—and then proceed to business.

The biological teacher in his class room says he must live, he must have his tools for his work, to which the idle student replies under his breath, "I do not see the necessity," but then few students are now idle, and this jibe does not sting any one! The examiner must have his normal human anatomy, and would ruthlessly plough any daring examinee who tried to sophisticate the meaning of the term "normal." I have often been struck with what I must call the intellectual audacity of a most eminent leader in physical science and mathematics, who is not unlike a certain great Church, which grants nothing to her adversaries but is not averse from taking. In his *Grammar of Science*, written with a pen dipped in hydrochloric acid, Professor Karl Pearson four times over, and perhaps more, has the courage to call the human brain in this twentieth century "normal." Has he never heard of the coming Superman of Mr. Bernard Shaw and other prophets? Thinking *sub specie aeternitatis* has he here in the West, and at a certain small epoch of time, any right to call the human brain "normal"? I can only long that there may be more normal brains such as Professor Karl Pearson's, and am almost inclined to echo the prayer of Moses, "Would God all the Lord's people were [such] prophets"! These comments on the term "normal" imply no complaint against its use, indeed are a claim for it, and I deprecate very much that form of criticism known in boys' schools, domestic circles, and among politicians as the *tu quoque* reply, and I hope the few ambiguous terms used in this book will pass the censor, and help the reader.

CHAPTER VII.

THE EVOLUTION OF PATTERNS OF HAIR.

SOME attention must here be given to the supposed mode of formation of individual patterns of hair, that is to say, their evolution. So here one has to move among the fields of hypothesis, without which detached facts of nature are useless to science.

The simplest pattern consists of a reversed area of hair appearing between two adjoining streams; the more complex are whorls, featherings and crests. No detailed description nor illustration of the former are required, but I have prepared a diagram to illustrate the latter (see p. 51.) (A) shows a whorl by itself; (B) a whorl, feathering and crest. The arrows at the sides indicate the direction of the adjoining hair-streams, the arrow in the centre of (B) the direction of the reversed flow of hair.

An understanding of the dynamics of a hair-whorl leads quite simply to that of a feathering and crest, for the two latter are only the results of the further extension of the battle of forces concerned in the whorl itself, and the end of their conflict. A whorl marks a point in the stream of hair where two contending forces have come into collision; on the one hand the centrifugal force of growth from each hair-papilla, the rate of which has been described, and on the other a certain centripetal dynamic force which may be either that of localised *friction, pressure, gravitation*, or *muscular traction*, directly opposing or divergent. Thus conceived a whorl may be looked at symbolically as a written treaty between two nations, one of which has defeated the other, and actually as a proof that the contending centrifugal and centripetal forces are in the state called the balance of power. But when the centripetal force of some habitual action prevails over that of the original force of growth in the hair, a whorl becomes extended into a feathering, and the length of this, metaphorically speaking, corresponds with the duration of open fighting, and terminated by a sharp crest when another and a decisive battle has been fought. A crest may again be looked upon as a "treaty." The whole process pictured here shows a battle followed by a treaty or truce (w) again a retreat (F) and a counter-attack (C) with a final treaty and peace.

This hypothetical treatment, with addition of some metaphors, does not carry us far enough to leave it thus to the tender mercy of that class of critic who relies too much on the "argument from ignorance." He tells us such a process as I have pictured may be true or not, and that no one can do more than leave the case open, and treat it like that of Jarndyce & Jarndyce where it would remain in Chancery till all of us concerned in the inquiry have returned to our dust. The critic might reasonably ask for experiments which will bear out the suggested views. But verification by calculated experiments is impossible, for, *ex hypothesi*, the variations or patterns which are described require long periods of time for their production. Such experiments being ruled out, the evidence in favour of the hypothesis must be sought in some region of the hairy coat of mammals where whorls, featherings and crests can be observed in all stages of their formation.

The Side of the Horse's Neck.

The field chosen for observation is, from one point of view, the most remarkable among all the numerous regions in the great series of hair-clad mammals. The side of the neck in the domestic horse displays all degrees and forms of whorls, featherings and crests in such variety as to be almost bewildering. I must have examined many thousands of specimens of this valuable large mammal in reference to this state of things on the side of its neck, and can only regret that I have not kept any record of them as to number or quality, and I fear the opportunity for doing so will not return in this country. There are three reasons for this choice

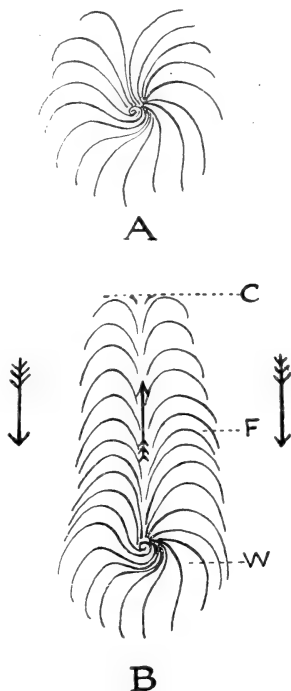


Fig. 2.—A. Diagram of a whorl.
B. Diagram of a whorl (w)
a feathering (F) a crest (C).

of field. In the *first* place there is or was an extensive supply of the specimens for examination ; in the *second*, the side of a horse's neck is a region where no extraneous or artificial agents, such as harness, except a bridle, can operate, and therefore Nature and the animal's habits have free play ; in the *third* the neck of a horse in its locomotive life is subject to powerful mechanical forces which are *constant*, literally speaking, while it walks, trots, canters or gallops. Here then, if anywhere, one may read the records, in indelible characters of hair patterns, the history of its active life and that of its ancestors, and here also one may reasonably expect to find these patterns in every possible stage of formation, from a mere rudiment to the most finished product in a whorl, feathering and crest—and *this is precisely what is found to exist*.

Even an observer not acquainted with the anatomy of this region who watches closely a horse in action cannot fail to notice how at every step taken there is a marked jolt of the neck produced in the neck by the impact of its hoofs with the ground and in supporting its heavy skull. I have computed several times the number of jolts that the neck of a trotting horse sustains, in my numerous rides behind various horses, during many hundreds of miles, and have reckoned the number which occur in a horse trotting for an hour, at the usual rate at which a doctor travels. This is on the average 6,000, and of course the numbers of jolts in walking, cantering, and galloping vary according to these different paces. But a great deal more of movement of the head and neck is observed beside the jolt at every step. See how the animal tosses up its head, twists it to this and that side for the mere *joie de vivre* when it is fresh, or, even when hindered by blinkers,¹ how he turns his head to look at every passing object in the road with his ancestral caution, how he will pass contemptuously a great horse-waggon or even now a villainous-looking motor lorry, but will peer at a beggar woman sitting beside the road, or a heap of stones, or a yapping cur ! All this vivid muscular work of a horse's head and neck hardly ceases while he is in action and at any rate not till he is dead beat, and the higher the courage and breeding of the horse the more frequent and brisk are his movements. Is it possible to conceive a region of the body of any large mammal where more numerous, varied, and powerful action of underlying muscles can

¹ Blinkers ought long ago to have gone the way of bearing-reins for draught horses. If a riding horse does not need them, no more need a draught horse be thus insulted, for very little intelligence and patience on the part of their drivers would have educated their excellent brains into indifference towards startling objects.

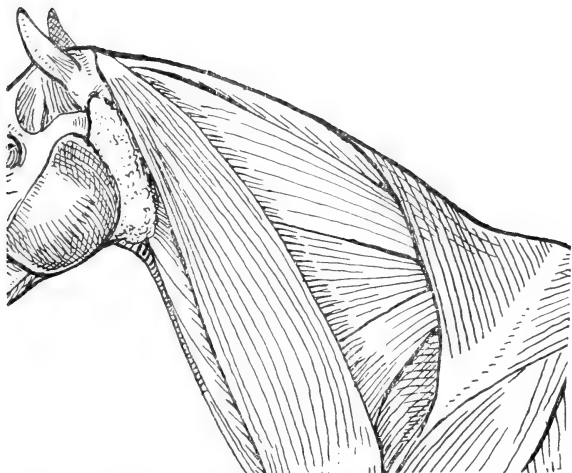


Fig. 3.—Superficial muscles concerned in the movements of the head and neck of the horse.

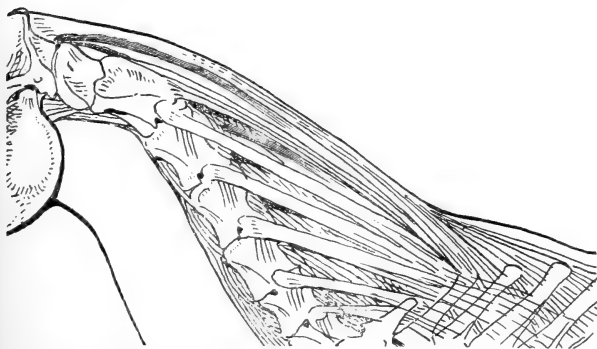


Fig. 4.—Deeper layer of the muscles concerned in the movements of the head and neck of the horse; the scapula removed.

be found playing their ceaseless tricks on the sober normal slope of hair in the skin which covers them? If there be any region approaching this I have not found it.

The main facts of the anatomy of the horse's neck must be referred to here, so that a better picture may be obtained as to the powerful forces which are found in conflict during the locomotive life of the animal. Fig. 3 shows the superficial layer of muscles concerned in the actions of its head and neck, and the manner in which adjoining muscles diverge from one another should be noted. Fig. 4 gives the deepest layer of neck-muscles, the shoulder-blade

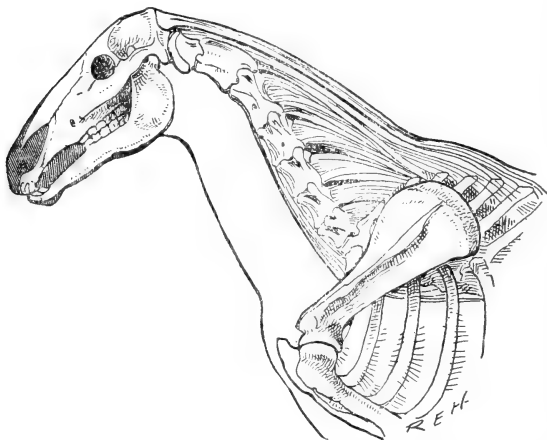


Fig. 5.—Ligaments and tendons supporting the head and neck of the horse.

having been removed, and Fig. 5 the immensely strong *ligamentum nuchae*, of yellow elastic tissue, which extends from the base of the skull to the great projecting spinous process of the lowest cervical and second and third dorsal vertebræ.

There are here indeed great forces for conflict—*first* a layer of strong superficial muscles, *second* a layer of smaller muscles which has not been figured, *third* a deep layer of muscles, and *fourth* a powerful, widely-spread and strongly-attached mass of

dense elastic tissue, adapted for supporting the head without muscular exertion, but by its elasticity allowing a downward jerk of the head and neck at every step. It is an exceedingly important structure for a domestic horse.

The Normal Arrangement of Hair.

So much for the active part played by a horse's neck and head, and for the simpler anatomical facts of the region involved. Before proceeding to describe the results of these as seen in the hair, it is well to make sure of a point which a critic might raise. "How do you know," says he, "that some of the variations in this highly variable region of the hair are not normal. What is the normal type here?" A very easy answer to this is found by studying, not only any Ungulate known, except the Gnu, but more particularly all wild Equidæ; and this reveals the fact that in all this series the normal slope of hair prevails here, that is to say, an even trend from head to shoulder. Variations in others, indeed, hardly exist, and I may add that the absence of variations here is a strong piece of negative evidence in my favour, for no Ungulate comes near the domestic horse for amount and activity of locomotion, which is indeed his *raison d'être*. He is the only one that has invented new patterns. But a little direct evidence can be brought which clinches this argument from inference based on ancestry. I made an examination, at the stables of Messrs. Tilling, at Peckham, of 100 consecutive specimens of hackney, for the purpose of ascertaining the proportion in that group of those that showed the normal slope on the neck to those with variations. In 62 of these the normal existed on both sides of the neck, 18 Normal on one side, and in the remaining 20 there were variations on both sides. If 100 specimens of horses contain 80 with one side and 62 with both normal the previous inference requires no further support.

Fourteen Varieties.

I have put together here, and described, fourteen out of a much larger number of the most instructive varieties of pattern that I have been able to collect during the course of many years and examination of several thousand horses. They comprise examples the mostly likely, as I think, to convey to the reader an adequate picture of the results of the strength, number and variety of mechanical forces in our present battle-field of hair. The diagrams almost speak for themselves, but a short written description will help to emphasise the salient points.

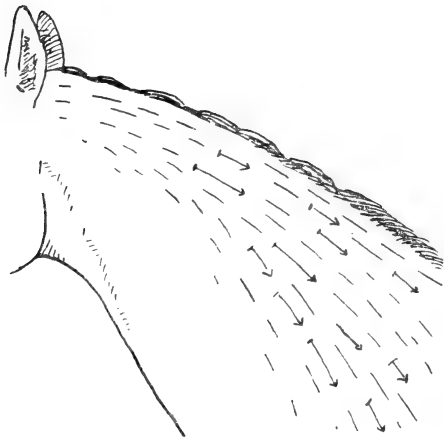


Fig. 6.—Side of Neck of Horse.
Normal type, hair-stream passing evenly in line of neck.—Bay hackney,
examined 3rd May, 1904.

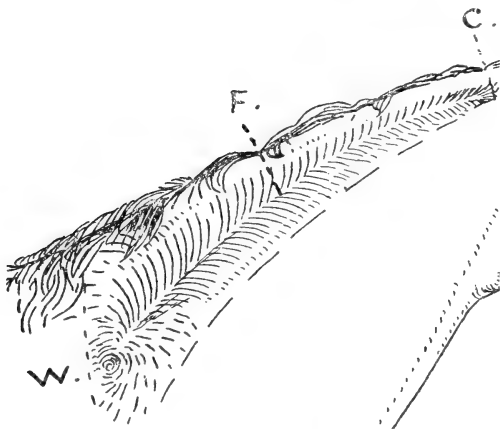


Fig. 7.—Side of Neck of Horse.
Complete whorl with wide feathering which extends from base of the
neck to the ear where it ends in a crest.—W.F.C.
Brown hackney, examined 12th January, 1904.

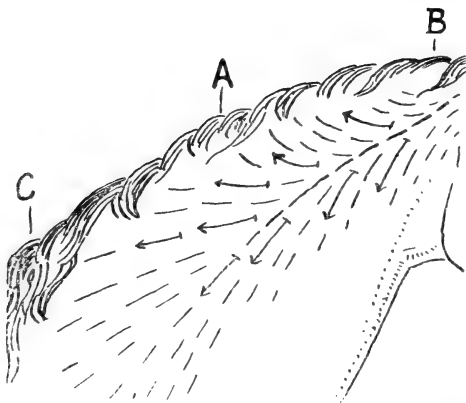


Fig. 8.—Side of Neck of Horse.

Offside, anterior portion of neck showing line of division, B to A, along upper border of sterno-mastoid muscle, normal arrangement from A to C. Grey pony, examined 15th December, 1903.

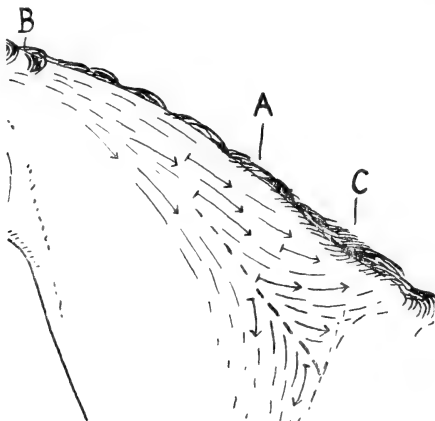


Fig 9.—Side of Neck in Horse.

Near side, winter coat, showing normal arrangement from B to A, where a division begins and extends along upper border of sterno-mastoid muscle to base of neck.

Brown hackney, examined 28th December, 1903.



Fig. 10.—Side of Neck of Horse.

Line of division of streams curving upwards to the mane near the base of the neck.

Chestnut cart horse, examined 9th December, 1903.

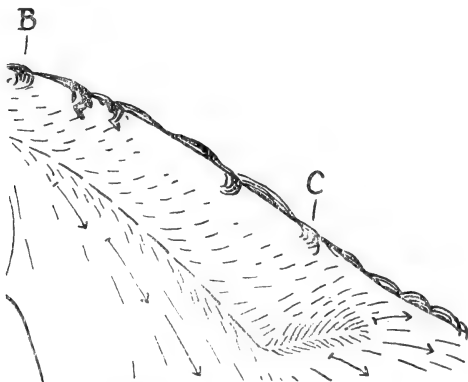


Fig. 11.—Side of Neck of Horse.

Near side, line of division along the upper border of sterno-mastoid muscle diverted at C towards the mane.

Bay cart horse, examined 11th December, 1903.

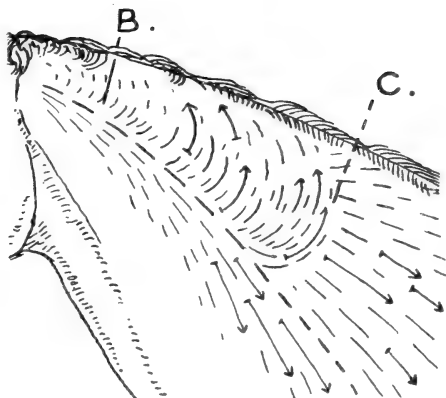


Fig. 12.—Side of Neck of Horse.

Near side, at C upward curve towards mane.
Brownish-yellow hackney, examined 18th August, 1903.
The same horse as appears in Fig. 13.

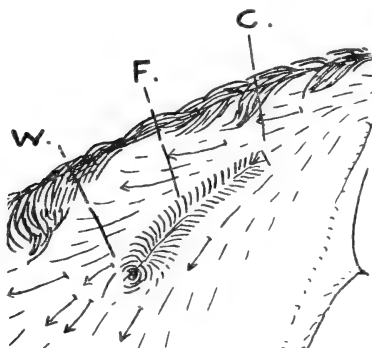


Fig. 13.—Side of Neck of Horse—same specimen as in Fig. 12.
Offside, fully developed whorl, feathering and crest W, F, C, lying
along upper border of sterno-mastoid muscle. Two stages of formation
of this form of pattern in one specimen.

Brownish-yellow hackney, examined 18th August, 1903.

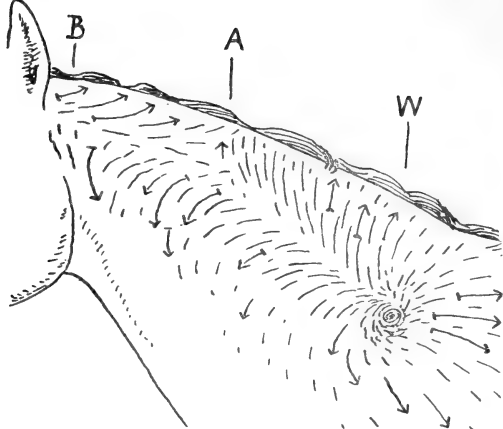


Fig. 14.—Side of Neck of Horse.
Near side, whorl (W) in place of common line of division, with wide forward feathering to A, where the hair streams diverge sharply.
Brown hackney, examined 19th November, 1903.

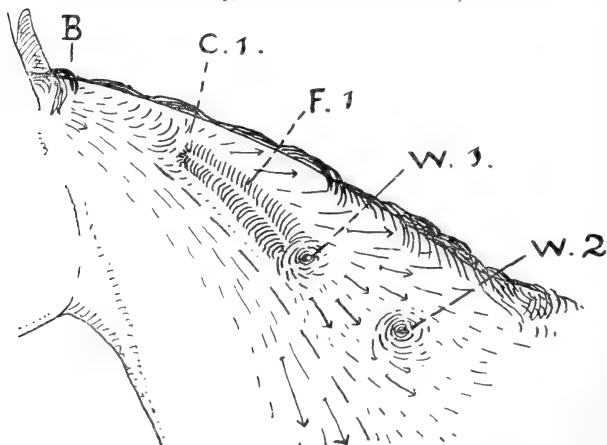


Fig. 15.—Side of Neck of Horse.
Near side, showing (B to C¹) diversion of hair stream towards mane (W¹F¹C¹) whorl, feathering and crest; W¹ to W² stream in normal direction W² a second whorl.
Chestnut cart horse, examined 1st January, 1904.

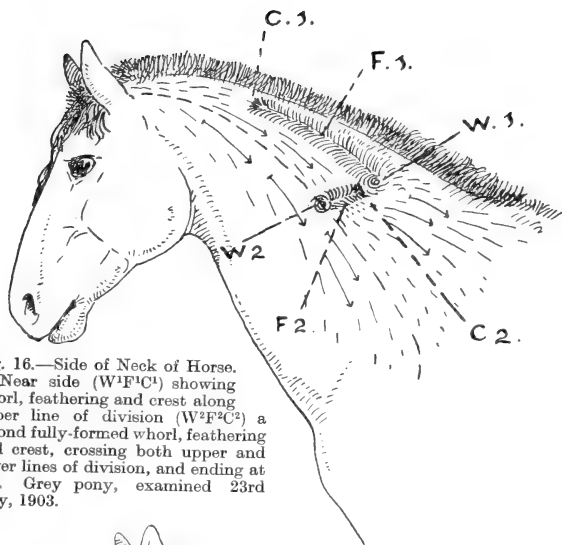


Fig. 16.—Side of Neck of Horse.

Near side ($W^1F^1C^1$) showing whorl, feathering and crest along upper line of division ($W^2F^2C^2$) a second fully-formed whorl, feathering and crest, crossing both upper and lower lines of division, and ending at W^1 . Grey pony, examined 23rd May, 1903.

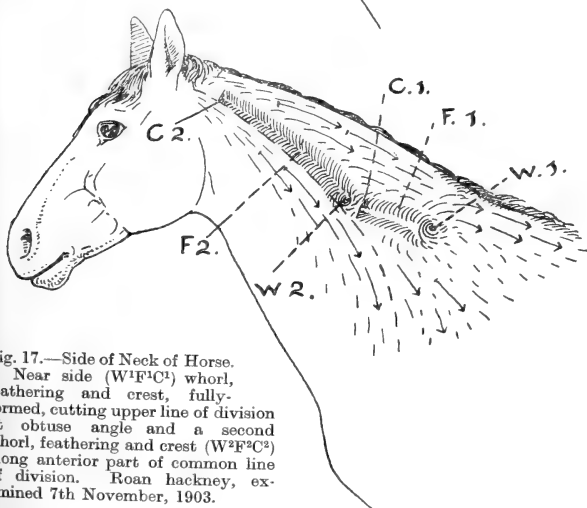


Fig. 17.—Side of Neck of Horse.

Near side ($W^1F^1C^1$) whorl, feathering and crest, fully-formed, cutting upper line of division at obtuse angle and a second whorl, feathering and crest ($W^2F^2C^2$) along anterior part of common line of division. Roan hackney, examined 7th November, 1903.

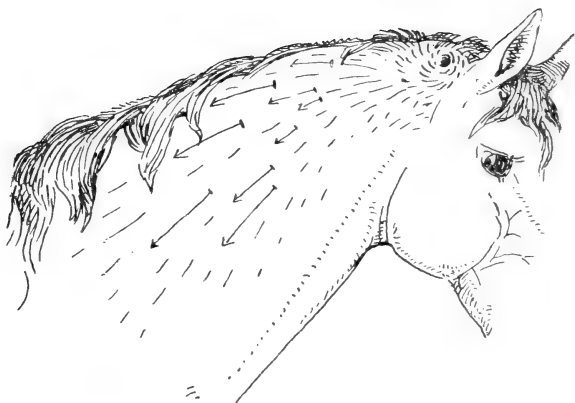


Fig. 18.—Side of Neck of Horse.
Off side, simple whorl, behind ear at edge of mane.

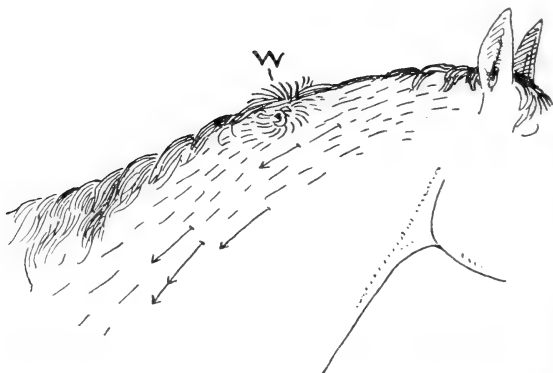


Fig. 19.—Side of Neck of Horse.
Simple whorl (W) at edge of mane midway between ears and base of neck.

There are pictured here the normal type, divergent hair-streams partially reversed, simple whorls in different regions, a whorl and feathering, whorls, featherings and crests, and these in several areas. It is a veritable portrait gallery in which is portrayed the earliest and latest stages of this family of fashions in hair on the horse's neck. They are grouped mostly in pairs.

Fig. 6 shows the normal slope and by its side Fig. 7 gives a view of the best specimen of a completed whorl, feathering and crest I have been able to examine, *the whole length of the neck being occupied by it*. So in this pair the normal and most extensive departure from it lie side by side.

Fig. 8 shows the way in which two streams of hair close up to the ears begin to diverge. Fig. 9 a similar divergence towards the base of the neck.

Fig. 10 gives not only a divergence, but a well-marked turn in the upper hair-stream and Fig. 11 the way in which this divergent turn of hair is being converted into a feathering.

Fig. 12 presents a stream of hair still more twisted from its course than that of Fig. 10, and Fig. 13 a whorl going on to a feathering which loses itself, without coming to an abrupt stop in a crest which is the more usual course.

Fig. 14 is a common type of whorl, feathering and crest in the most usual situation. Fig. 15 a rarer and more complicated instance of a simple whorl, a gap and then a whorl, feathering and crest in the same "critical area."

Fig. 16 and Fig. 17 are rare cases of irregularly placed double whorls, featherings and crests, and give evidence of unusually complicated traction of adjoining muscles underneath this battle-field of hair.

Figs. 18 and 19 show a simple whorl, situated at the very edge of the mane, a very "critical" area because this looser and heavy part of the neck is very much subject to jolting during the horse's action.

I have little to add to the graphic evidence afforded by these pictures, each of which I observed noted and sketched as the bearers of them came before me during many years of a "Captain-Cuttle-like" disposal of some of my leisure. No clearer proof can be desired of the view here advanced, that habit or habitual muscular action, and jolting, is the cause of the varied patterns in this field, and that according to the Law of Parcimony no other is required, this canon of Occam being expressed more succinctly—*Neither more, nor more onerous causes are to be assumed than are necessary to account for the phenomena.*

CHAPTER VIII.

CAN MUSCULAR ACTION CHANGE THE DIRECTION OF HAIR IN THE INDIVIDUAL ?

It might seem unnecessary to most persons who are good enough to follow this inquiry that the question asked above should receive an explicit answer. We all know, of course, how a man's hair is said to stand on end in excessive states of horror or rage, and how a short-haired terrier's back bristles at the sight of certain foes. But it is not so simple a matter to show that the direction of the hair is permanently changed. I submit that the persons I mention are right in their opinion for this work contains evidence throughout that muscular action beneath the skin is the efficient cause in many regions of the formation of hair patterns. But like Kirkpatrick when Bruce struck down the Red Comyn we had best "make sicker," and give as much evidence of the affirmative question as any critic can demand.

Hairs of Human Eyebrows.

As in the previous chapter I chose an open and plain field for the evidence bearing on the formation of whorls and the like, so here I turn to one still more clear for him who runs to read. In these days old men are of less account than in earlier and simpler times, but I claim to have found "a new use for old men" as I had almost thought of calling this chapter. In this somewhat neglected group we have an almost unlimited number of specimens for examination, and in their eyebrows they furnish a valuable field for tracing some striking results of underlying muscular traction.

Darwin made one of his few mistakes when he included among rudimentary and inherited structures¹ those few long hairs which are often seen in the eyebrows of man, looking upon them as representatives of those found in some species of macacus and the chimpanzee. That great and modest man was, I am sure, not in the habit of making much use of the looking-glass—not more than women who, as we know, rarely do such a thing. But if he did

¹ *Descent of Man*, p. 19.

he would have observed in his own splendid frontal region and brows excellent examples of the phenomena which form the subject of this chapter. This I know, though I never saw him in the flesh, for it so happens that in the great volume published in the jubilee of The Origin, and called *Darwin and Modern Science*, two good photographs of him, at the ages of thirty-five and about seventy-one are reproduced. These both show, but the later one much more clearly, good examples of these long and not very ornamental aberrant hairs. Thirty-five years of arduous thought and work had told their tale on him and twisted from their normal paths the lengthening thickening hairs of his eyebrows.

Also, if he had looked a little beyond the eyebrows he would have seen some very deep wrinkles of the skin on his forehead and round his orbits. It is these two groups of facts, wrinkles and twisted, changed hairs of man's eyebrows, which give the answer to the question "Can muscular action change the direction of hair in the individual?"

In 1903 I drew the attention of the Anatomical Society of Great Britain and Ireland to these two groups of facts under the title "Notes on the Eyebrows of Man," and presented some large drawings of individual elderly men of my acquaintance, and the present chapter is only an extension of that little piece of work.

No area of the mammalian skin is so useful and easy to follow as this in answering the present question, for though the previous chapter supplied part of the answer in a very fruitful field, the proof still remained one of "tremendous probability" and not more. But in the frontal and superciliary region of man there is complete proof of the truth of the affirmative answer, as I shall show.

Here again we must encounter our old friend the normal slope of hair. As I stated in 1903, "The normal arrangement of the hair on the eyebrows of a moderately hairy subject is as follows: in the middle line the hairs of the two sides tend to meet and form a somewhat confused group of hairs; passing away from the middle line the hairs assume a nearly sagittal direction, then become more sloped away, and a sharp change in the direction of the *frontal* and *orbital* streams brings the remaining hairs into that regular accurate arrangement of a united stream so characteristic of a hairy subject, and this passes along the superciliary ridge to the external angular process"—all of which can be seen at a glance by any one who looks closely enough, as with the eyes of a lover, for example, at the brows of a dark-haired maid or youth. In the young these hairs lie close to the skin, and with that very interesting group of persons we have no more to do here, except

for one piece of practical advice to them which they will find at the end of the present chapter.

Evidence from Artists.

More than one kind of evidence may be brought forward in this case, and I propose to "put in" a certain class of witness that not the most acute cross-examining counsel, Daniel O'Connell, Hawkins, or even Sergeant Buzfuz, can shake. I pity that young man or woman to-day who has not mended several holes in his education by reading the books of Dickens and Lever in editions illustrated by the immortal Phiz. If I do no more for him by this passage than induce him to mend such holes I shall have been of some use to his mind. For my part I look upon Phiz as far superior to Hogarth or Cruikshank in the fidelity to nature of his drawings of the faces of his numerous characters, especially the old men. Look through *Dombey & Son*, *Bleak House*, *Pickwick Papers*, *Barnaby Rudge*, *Tom Burke*, *Jack Hinton*, *Harry Lorrequer*, *The O'Donohue*, and, perhaps best of all for the illustrations, *The Knight of Gwynne*. Examine, with a lens if necessary, the delicate way in which Phiz shows the projecting hairs on the eyebrows of his many elderly men, and note at the same time the truth to scientific fact which he shows in his *female* characters, for only in the drawings of "Mrs. Gamp proposes a toast" and of Mrs. Pipchin in "Paul and Mrs. Pipchin," and one or two doubtful instances, can I find that he represents even his elderly women with this feature of their eyebrow hairs. But see Captain Cuttle and Mr. Bunsby in "Solemn references to Mrs. Bunsby," both with strongly-marked shelves of hair sticking out from the brows, Captain Cuttle in "The shadow in the little parlour," one of the fat coachmen in "Mr. Weller and his friends drinking to Mr. Pell"—the sharp brush projecting from the brow of Bagnet in "Mr. Smallweed breaks the pipe of peace," that of Vholes in "Attorney and Client, fortitude and impatience"—(the equally remarkable absence of this feature in Pecksniff, Chadband and Skimpole, men without character or feeling)—Gashford in "Lord George Gordon," the fat figure in "The Gallant Vintner," Pioche in "Minette in attendance on Pioche," the courtier in "Louis XIV. and de Genchy," "The death of Shaun," the blind man in "Joe the mighty hunter," the right hand figure in "Mr. O'Leary creating a sensation," Sir Archibald McNab in "A fireside group," "Roade's return to O'Donoughue Castle," Sandy McGrane and Old Hickman in "Sandy expedites the doctor," Daly in "Daly bestows a helmet on Bully Dodd," the knight in "The Knight is taken Prisoner."

Another witness to the scientific facts of the frequent presence of these hairs on the eyebrows of elderly men, and the rarity of them in those of women, is the dear friend of our youth, our friend even to hoar hairs, the *Book of Nonsense*, by Edward Lear. Here in 110 vivid drawings of several hundred characters, each of them sketched with a few bold strokes, is inscribed again and again this peculiar feature. Look at the "Old man with a nose," the "Old Man of th'Abruzzi," the "Old man of Melrose," the "Old man of Calcutta," the "Old Person of Anerley," the "Old Person of Chester," all with strange and striking bushes of long hairs standing out from their brows. Again see how hardly one of the female characters shows a trace of it even in that most truculent "Grandmother of the Young Person of Smyrna" who threatened to burn her, though her vertical wrinkles are formidable, or in the remarkable face of the wife of the "Old Man of Peru." The "Old Lady of Prague" shows it in a moderate degree. Support of this kind may be trivial, and so will the opposing counsel say is that of a burglar's finger-prints, but, *quâ* evidence, it is as strong as that which commits the criminal to a prison on this modern proof. No one can suppose that Phiz and Lear fifty or sixty years ago had a prophetic and treacherous insight into the harmless labours of a man in the year 1920 who would exploit their labours to the advantage of his hypothesis, and that they faked their caricatures for such a purpose. This is the only alternative line for Sergeant Buzfuz to take unless he acknowledge the facts to be facts, and betake himself to abuse of the plaintiff's attorney.

Eyebrows Interpreted by Wrinkles.

When one comes to the interpretation of the curious shapes taken by these hairs one is not left to inference, for Nature has put some indelible stamps on the forehead and round the orbits of the men examined. These are wrinkles which have been long in preparation and only begin to show themselves fully when the "evil days" have come, in the 'fifties, 'sixties and 'seventies.

I will describe the wrinkles first, and then their results, with examples, in the numerous fashions of the hairs. Wrinkles are of two kinds, pathological and physiological, in other words the former are the results of degeneration and wasting of the subcutaneous fat and loss of its normal elasticity, and are found in the faces of nearly all men and women, with advancing age, and they are the subject of much distress in the fair sex and a good deal of "beauty doctoring." The latter are the result of long-continued and repeated action of certain small muscles. The former are

numerous, shallow and fine, the latter few and comparatively deep. The difference between elderly women and men in respect of the projecting hairs is not that men have many more physiological wrinkles, but that the hairs of women in this region do not stiffen and grow long nearly so much as those of men.

There are three groups of wrinkles found on the human forehead and face, *vertical*, *arched* or horizontal and *orbital*. This division of wrinkles is a natural one, for each group is produced by the action of different muscles, the *vertical* by the corrugator muscle, which is a narrow band passing from under the frontalis muscle inwards, where it is attached to the bone between the two eyebrows; the *arched* by the action of the frontalis muscle, one which moves the scalp and in doing so elevates the eyebrows; the *orbital* by the elliptic orbicularis muscle which closes the eyelids. These muscles are shown in Fig. 20.

Vertical wrinkles are found in the central region of the forehead and sometimes occupy the middle line with a deep furrow, more often they are bilateral and symmetrical, near the inner fourth part of the eyebrow, and sometimes they are placed at different distances from the middle line.

Arched wrinkles extend over the forehead in a series of lines which are usually concentric with the curve of the eyebrows, but are sometimes nearly horizontal.

Orbital wrinkles may lie in a radiating plan all round the outer lower and inner borders of the orbit, and in some persons they are found lying over the curves of the orbicularis muscle itself.

Some Examples.

The variations in the long hairs of men's eyebrows present some very singular tufts, and I have added below nine figures of certain cases examined and noted by myself, and these are, I hope, plain enough without any more detailed account than is given in the few words describing each.

Unless one's attention be specially directed to these aberrant hairs, which are extremely common, one would not expect that hairs could be so variously twisted by muscular action beneath them. You may see a tuft of long hair projecting from the plane of the eyebrows towards the inner end, looking like a small horn, and I have measured individual hairs in elderly persons and found many an inch in length and a few an inch and a half. Such a tuft gives a fierce look to the countenance if the hairs are bushy and plentiful. The celebrated Dr. Keate, the flogging Head of Eton, a fiery strenuous person, was noted for the extraordinary long

horn of thick hair in his eyebrows, which he appeared to use as a supplementary finger to point to this or that object of his terrifying attention. You may also see a man with a great drooping curtain of hairs overhanging his eyes, half hiding the upper lids and eyes. Another will show at the outer end of the eyebrows a bristling bush of hairs turning upwards in the aggressive manner of Wilhelm II. of evil memory, or of Mr. Roosevelt in former times. Again the outer points of the eyebrow hairs may turn downwards like a cavalry moustache, or the hairs may stand out at right angles as a level shelf. The fashions of these "orbital moustaches" appear to be as numerous as those of the upper lip.

A Conflict of Forces.

If the eyebrows are studied in the light of the three muscles displayed in Fig. 20 it is seen to contain an interesting congeries of small forces in conflict. (1) The *frontalis* moves the eyebrow directly upwards. I had a friend once about seventy years old who was a very vigorous, strong-willed man and he spoke with decision and energy. It was most interesting to watch how his *frontalis* muscle strongly and frequently contracted as he spoke and drew up his eyebrows so that one might, as it were, measure the strength of his expressed convictions by the rate of action of his *frontalis* muscle! (2) The *corrugator* draws the skin of the eyebrow inwards to the middle line thus acting at a right angle to the line of the *frontalis*. (3) The *orbicularis* in the upper part directly opposes the action of the *frontalis* and in the lower acts "on its own" in closing the lower lid. This little spot is a Hill 60, destroyed at the battle of Messines, and has been the scene of much fighting throughout life, and it bears abiding witness in the twists and curves of the long hairs to the severity of the struggles. These actions of the three contending muscles are involuntary and of a reflex character, and much employed in such habits as those of knitting the brows or in elevating or depressing them, all this being set going and controlled by cerebral action. Incidentally then the preponderance of one or more of these actions over others, as shown in the hair, is evidence, as far as it goes, of the disposition and character of the possessor. So that between the wrinkles and the twisted hairs of his brow the elderly man, and less so the woman, carries about an engraved statement, for his friends or enemies to read, of his natural disposition and his acquired habits, in a limited field—his written character!

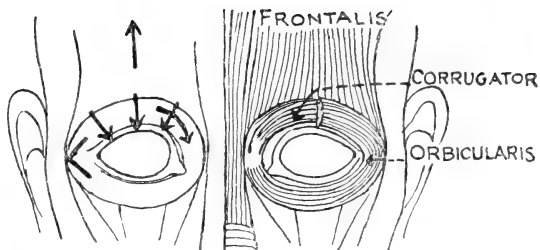


Fig. 20.

Muscles surrounding orbit with lines of action. Left—muscles concerned in movements of parts round orbits. Right—lines of action of these muscles indicated by arrows.



Fig. 21.—C. B. æt 81.

Hairs : Thick and bushy eyebrows. At junction of outer and middle third of each side the thick hairs turn abruptly downwards in a tuft and cover the upper lid.

Wrinkles : Arched and lateral fairly well-marked, one very deep, central and vertical wrinkle.

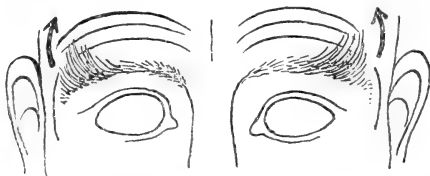


Fig. 22.—G. W. æt 79.

Hairs : On each side at junction of outer and middle thirds a definite wisp of hair turning upwards.

Wrinkles : Arched and orbital well-marked, central wrinkles hardly visible

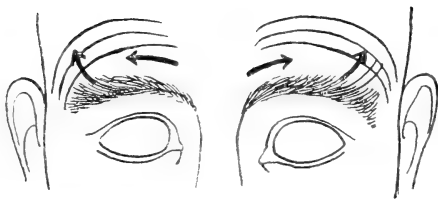


Fig. 23.—F. F. *æt* 57.

Hairs : Left side two long hairs from 1 to $1\frac{1}{2}$ inches long, turned sharply up at outer end of eyebrow. Right side short hairs turned upwards.

Wrinkles : Strongly marked, curved, orbital wrinkles round outer half of each orbit. No other wrinkles.

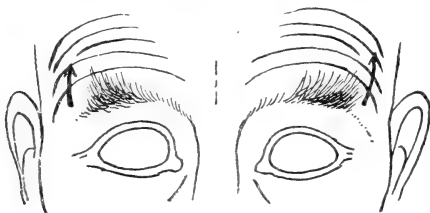


Fig. 24.—B. W. *æt* 69.

Hairs : on both sides, projecting tufts at junction of the middle and outer thirds of eyebrows, hairs an inch long. The outer fourth of surface bare of hair.

Wrinkles : Vertical hardly visible. Arched wrinkles numerous and especially deep towards the temporal region.

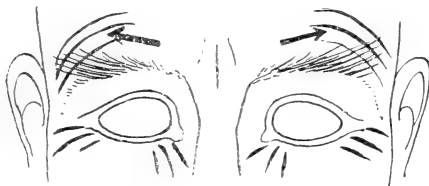


Fig. 25.—T. R. *æt* 57. Voluble talker, twitches eyebrows in talking.

Hairs : Thick and stand out stiffly from eyebrows, turning slightly upwards in outer third—almost absent from inner third of surface.

Wrinkles : Vertical faint; arched deep and long, equal on the two sides, orbital, on each side two groups of deep radiating wrinkles, beside many small lines.

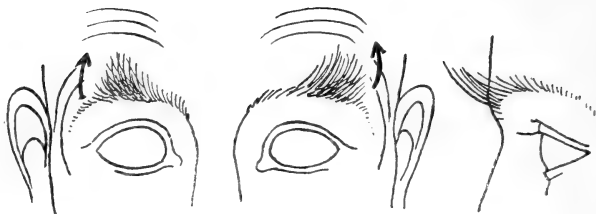


Fig. 26.—A. P. æt 63.

Hairs : On each eyebrow at about the junction of the middle and outer third, there is a remarkable tuft measuring 1 to 1½ inch projecting from plane of eyebrow somewhat upwards, scanty hair on outer third.

Wrinkles : Smooth open forehead, with moderate-sized arched and orbital wrinkles. Vertical wrinkles hardly visible.



Fig. 27.—G. G. æt 54.

Hairs : Right eyebrow upward twist of hairs on outer half, left eyebrow hairs lie straight: project, on both sides, well away from plane of eyebrow.

Wrinkles : Arched on right side more numerous and extending higher than on left. No vertical wrinkles.

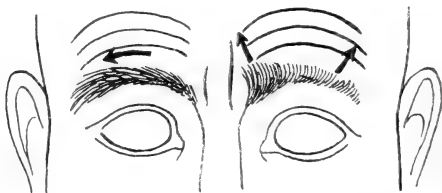


Fig. 28.—R. N. æt 65.

Hairs : On right side hairs long and projecting nearly in horizontal direction, on left sharply turned up at inner end and rather less so at outer.

Wrinkles : on right sides, three faint arched wrinkles, one vertical, short and small. On left, three deep arched wrinkles, one vertical, deep and long.

A Side-Issue.

This conclusion brings me to the piece of gratuitous advice I offer to the unmarried reader. It will be more likely to appeal to the woman than the man, I believe. Let such an one who is contemplating matrimony make a short study of wrinkles and the long hairs if possible—unfortunately she cannot do this of her prospective mate if he be at all young, for neither of these features will be pronounced as yet. I recommend instead a study of the wrinkles and hairs of the father and mother and a deliberate summing-up of the evidence in this way. If she wishes to have a cheery, genial, hopeful companion in life like B. W. (Fig. 26) let her seek as many arched wrinkles in his parents as possible and avoid very deep vertical wrinkles. If she be herself of that disposition she will want a mate of different qualities and may venture on one

Fig. 29.—B. F. *æ*t 52.

Hairs : On both sides much twisted downwards, producing shelf over eye.
Wrinkles : None on forehead ; strongly-marked concentric orbital wrinkles on both sides.

whose balance of family wrinkles inclines to the vertical, *see* Fig. 28, R. N. She can risk that, and perhaps get a more capable and strenuous comrade in life's battle. But let her beware of him whose wrinkles are all of the vertical kind ; for he will be thoughtful, moody, abstracted and not too good-tempered. I would rather myself join my fortunes to one who could claim a large share of arched wrinkles.

After this digression, which follows logically on the facts and arguments of this chapter I am now in a position to affirm that *changes in the direction of the hair in the individual can be caused by muscular action.*

CHAPTER IX.

HABITS AND HAIR OF UNGULATES.

Horses.

THE Ungulate order has been variously divided by zoologists, and is still said to be composed of two main sections, even-toed and odd-toed Ungulates, with the addition of a good many "outsiders" if one may use the term.

These sections form two sub-orders, and the division suits my purpose here very well. I take the odd-toed sub-order of the Ungulata Vera first.

Lessons from the Domestic Horse.

The domestic horse is the only member of this section that requires detailed attention, and its value for studying the direction of the mammalian hair is great, on account of the immense number of specimens available, the quality and varied distribution of its hair, the size of the animal, and, most of all, our intimate knowledge of its habits of life for many thousands of years.

Many volumes have been written by man about this, his best and second oldest friend among lower animals. His ancestry, his story as servant of man, his virtues, strength, speed, intelligence, his use for war and peace, his colour, varieties of breed and money value; his anatomy, physiology, pathology, his medicine and surgery have all been written by many able men. Indeed before the great revelation of what man can be and do that the great war has given us, many observers of mankind were prepared to adapt the saying of a French cynic and to declare: "The more I see of men the better I like horses." Swift at any rate came near this in his bitter account of a voyage to the Houyhnhnms, which lasted sixteen years and seven months, towards the end of which he said: "For who can read of the virtues I have mentioned in the glorious Houyhnhnms without being ashamed of his own vices, when he considers himself as the reasoning governing animal of his country?" But in all these writings, even in that last striking book by Mr. Roger Pocock, *Horses*, little or no attention is given to the patterns of its coat from the point of view of science. I remember reading

a paper on this subject many years ago before a distinguished company of veterinary surgeons, and though they had glanced at these patterns in a passing way, as peculiarities, no real knowledge of them nor attempt to understand them was shown by this body of experts. They were too "practical" for this view of things. I may remark here that many of the most vocal and active among us, and especially the Germans, have been overmuch disposed to study science *ad hoc*, for its commercial and military value, though here, as elsewhere one must be tolerant and each follow his own taste, seeking light, more light. One must live and let live.

The horse does his work *coram publico* in every street of every town, in fields, roads and race-courses, and displays on his hairy coat some graceful patterns which are at the same time subjects for scientific inquiry, and brands of his long servitude to man. I have examined many thousands of horses in some twenty years with never failing interest. Belonging to the large family of Equidæ, including asses, zebras and quaggas, he is the most highly-developed of them all. His habits first, and then the most notable of his hair-patterns must now be considered.

Some Habits of the Horse.

He has few habits which bear on the present subject, and of these his active habits of locomotion are far the most important. He has his share of passive habits, for he stands many hours a day, and often sleeps standing, and he does his share in lying down, though Mr. Roger Pocock says he takes no more than four hours' sleep in this attitude. His rule in lying down is to "lie anyhow," if one may so describe it, and thus his two passive attitudes of standing and lying, have little or no bearing on the questions before us. His glory is in his gallop, canter, trot and walk. His business is indeed a *going concern* in more than one sense, perhaps in three. The world is moving fast in its old age, and some men are calculating how long it may take for him to become as nearly extinct as the quagga.

With the clue given to this inquiry in Chapter VI. we need have little difficulty in tracing the manner in which his locomotive life, ancestral and personal, is engraved on his hairy coat. We shall bear in mind the *primitive direction of his hair, hair-streams, lines of least resistance*, and the powerful forces of *underlying traction* of muscles, opposed or divergent.

It is, of course, most convenient to examine a specimen with a fine, short coat rather than one with its wild and more shaggy hair remaining.

The two regions where the play of great forces comes most powerfully into action during locomotion are round about the elbow-joint (which we should be disposed to call the shoulder) and the hip-joint, in which regions the range of extension and flexion, as well as the number of muscles engaged, is much greater than at any other part of the limbs. It is in the neighbourhood of these

two regions that the most characteristic of all the patterns of hair are found, and the names given to the patterns (whorls, featherings and crests) in these critical areas are *Pectoral* (Fig. 30) and *Inguinal* (see Fig. 31) with a third (G, H, I, Fig. 31) which is called *Axillary*, and is not constantly present. The main muscles involved in Figs. 30, 31 are shown in Fig. 33. The *Frontal* (Fig. 32) is another of the critical areas, *indirectly* concerned in locomotion, and will be considered first.

The *Frontal* pattern forms the star on a horse's forehead, often very noticeable when the hair of it is white. No detailed description is required if the illustration of it in Fig. 32 be studied. It is enough to

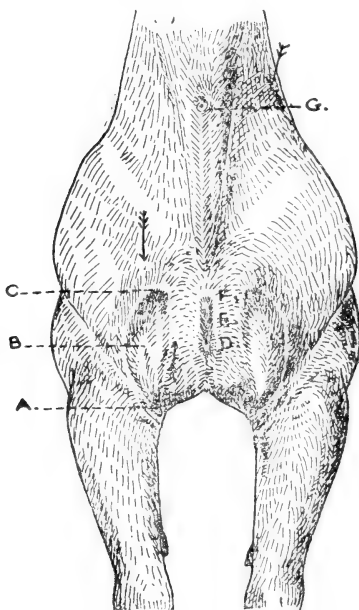


Fig. 30.—Front view of horse showing pectoral pattern A, B, C.

point out that it lies at or very near the level of the eyes, sometimes a little above and sometimes a little below this, and there is occasionally a double whorl, the second lying above the normal one.

Fig. 32A shows the muscles of the fronto-nasal region of the horse and the manner in which the skin of this central region is pulled upon in divergent and opposing directions, by a long muscle,

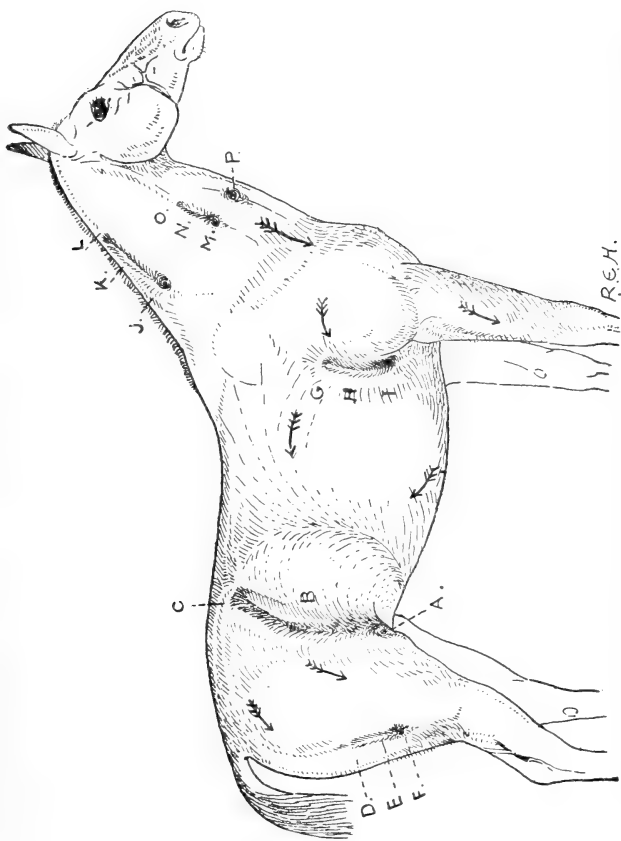


Fig. 31.—Side-view of horse showing inguinal whorl, feathering and crest A, B, C, and axillary whorl, feathering and crest, G, H, I.

called the *Maxillaris*, downwards and outwards, by a small thick muscle, the *Corrugator*, inwards, by a deeper and more oblique muscle, the *Nasalis*, downwards and inwards, and a little more remotely by the *Temporal* muscle, and the *intrinsic muscles of the mobile ears*. There are thus at least five muscles on each side, all pulling more or less against one another on this much-disturbed

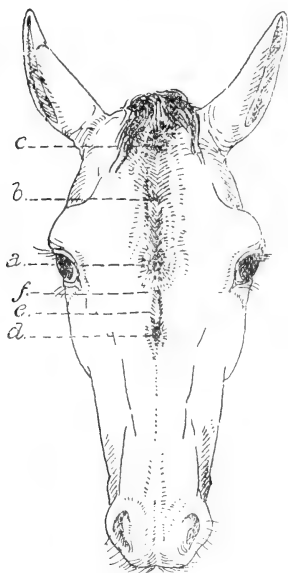


Fig. 32.—Frontal region of horse with frontal whorl (a); feathering (b); crest (c).

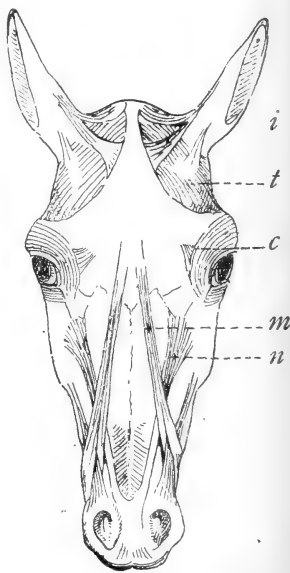


Fig. 32A.—Muscles of the fronto-nasal region of the horse.

area of skin. The struggle has been long ago given up and a compromise arrived at which is registered in the frontal pattern.

Now if anyone doubts whether these comparatively small muscles act often or strongly enough to produce effects on the hair over them he need only consult Mr. Roger Pocock's book to understand the story of this battle of small forces and its result on the hair.

In his wild state the horse is dependent to a remarkable degree

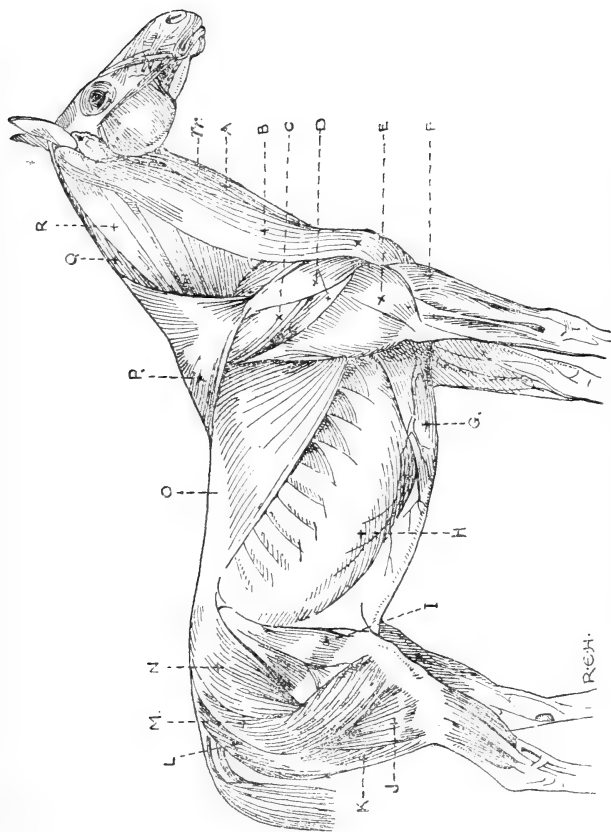


Fig. 33.—Side view of horse, showing chief superficial muscles.

to his sense of smell for his safety from foes (Pocock), and very much less so on his sight. Indeed that writer says his range of good vision is about six yards. At that range his sight is of great value to him for protection from certain of the dangers of his life, and we see in a domestic horse to-day the evidence of his past wild life by his rapid and keen glances at objects at the sides of the road, both when we ride and drive him. His *corrugator* muscle must be almost constantly in action. But his sense of smell is the sling and stone with which he encounters his Goliaths before they can get near him, and he ceaselessly expands and draws up his flexible nostrils employing his *nasalis* and his *maxillaris* for snuffing the air. He has also much useful protection from his sense of hearing and we all know how those mobile ears of his are hardly ever at rest, pointing now forwards, now backwards, and again outwards, as he goes on his way. The degree of these movements is largely a matter of individual character and breeding. The case for a conflict of forces in this region is, I submit, fully made out, and it is easy to see that a radiating pattern of hair, such as there is in the simple whorl, is only the natural outcome of all this complex muscular action. The extension of the whorl upwards in the shape of a feathering which is sufficiently common, indicates that the struggle has been carried beyond the original battle-field by the muscles of the ears.

The *pectoral* (Fig. 30) pattern lies over the great fleshy masses formed by the pectoral muscles, which draw the fore-limbs upwards and inwards in conjunction with others in the actions of flexion and extension of these limbs. The patterns, A. B. C., are wide expansions of reversed hair beginning in the whorl (A), extending (B) upwards and terminated in a crest (C). This pattern is, like the frontal, invariably present in a domestic horse, and is shared by many other ungulates such as deer and antelopes, as mentioned in the appendix of a small book¹, I published in 1901. But in none is it so striking or definite as in the horse. The contractions of these pectoral muscles and their jolt at each step are easily observed in a trotting horse. It is interesting to compare this pattern on the horse's pectoral region with what is found on the closely allied ass and mule. In the horse it is long and wide and never absent, and is especially well-developed in high-stepping horses whether cart-horses or others selected because of their high action in trotting. Its size, indeed, is a measure of the activity of the pectoral muscles and flexors of the fore-limb. In the ass it is

¹ *Use-Inheritance*. A. & C. Black. *Direction of Hair*.

often absent, and, when it is present, it is rudimentary ; in the mule it is more frequently present than in the ass, but does not approach the pattern of the horse for size. These degrees of development in horse, ass and mule correspond closely with the locomotive habits of the three animals.

The *inguinal* (Fig. 31) pattern is one which the most casual observer of a horse cannot fail to notice, and it is so graceful in its shape as to add to the many beauties of its possessor. But in spite of this no breeder of horses has ever taken this pattern as one of the "points" of the animal, so that here again selection, even of the artificial kind, has had no share in its development. It is but a by-product of the locomotive life of the horse, and a very ancient character, for it is present in Przewalski's horse, a probable ancestor of *Equus Caballus*. A domestic horse without this pattern would be a freak of Nature. It occurs in *equus hemionus*, the Thibetan wild ass, but not in *zebras* or in the *quagga*.

The inguinal pattern deserves rather more description than the two others. It is shown in Fig. 31 as A. B. C. and the muscles which produce it and govern its development are shown in Fig. 33. It starts in a whorl (A) at the fold of skin which passes from the lower part of the abdomen to the hind limb. This radiates and expands into a bilateral and symmetrical expansion shaped like the barbs of a feather. This proceeds upwards in the inguinal hollow in a direction which curves gently with the concavity forwards, dividing the trunk of the animal from the great rounded mass of muscle forming the hind quarters. It extends upwards to the level of the iliac crest where a projection covered by muscles can always be recognised, and over this "iliac crest" of the anatomist it terminates abruptly in a ridge or crest of its own, lying parallel with the long axis of the trunk. It is very pretty to see above it the hair-streams from the back of the animal breaking away like two currents of water on either side of an outstanding rock, the anterior passing with a wide curve forwards and downwards along the flank and the hinder one losing itself more gradually in the original course of the hair-streams of the hind-quarters. No illustration or verbal description gives so good a picture as one can get from inspection of the smooth coat of any well-developed domestic horse.

When a few trotting horses are watched by an observer who bears in mind the accompanying pictures of the muscles and the inguinal pattern it can be seen at once how all the conditions are present for fulfilling a gradual change from a primitive slope of hair to these highly-developed patterns, if he has also followed

the conclusion reached in Chapter I. that *muscular action can change the direction of hair in the individual*. If at the same time the degree and extent of the jolt which occurs here at every step be noted, it is seen to be sharply limited to the area covered by this pattern, and ceasing, as it does, abruptly and significantly at the level of the iliac crest. The forward range of the jolt, easily seen in a thin horse, is much wider than the backward, and marks out very closely the extent of the forward curve taken by the anterior hair-stream as it descends from the crest. One may also remark that there is a small but interesting point which one can see during or after a shower of rain, for then the flank of a horse presents a curious distribution of the moisture. At the very point where the forward stream joins the main stream from the thorax and abdomen a definite line of darker moist hair is to be seen and the moist-looking surface is limited to the stream of the trunk and separated from that of the flank. This line of demarcation clearly indicates the place where the *forward jolt* terminates during rapid movement.

The Domestic Ass and Mule.

There are two closely related animals, the domestic ass and the mule, which ought to show this inguinal pattern if affinity and variation could be fairly invoked to account for it on the theory of selection. These are also animals whose mode of life is locomotive, but in a much less degree than the horse and their paces are quieter and less free in character. What then is found in them as to the size or persistence of this pattern? In the ass it is absent or nearly so (I have found one example of its presence), and in the mule it is variable and never occupies more than half the area of that in the horse. These facts agree closely with the hybrid character of the mule and the differing activities of the horse, mule and ass. The pattern in Przewalski's horse is small and oval and resembles that of the mule. The *onager* (*equus asinus*), which is very much like these three domestic animals in form, has an inguinal pattern, much less in size indeed than that of the horse, but well-defined, and this fact is in keeping with its character for remarkable fleetness of foot and activity. The three zebras, Mountain, Grevy's and Burchell's, show no inguinal pattern, in spite of their *power* of rapid locomotion and resemblance in size and form to the horse. Though they have that power they exercise it in their wild lives for their own sakes alone, in the intermittent way which is bound up with their habit of life, and not for the sake of man, as in the case of the horse.

The pectoral and inguinal regions of the domestic horse are two of the most valuable fields in the mammalian body for studying the formation by muscular action of patterns of hair, for this animal is the locomotive animal *par excellence*. Here the process has been carried to the extreme limit, and these two are prominent examples among the characters to which I drew attention in a paper published in the *Proceedings of the Zoological Society of London*, "On proposed additions to the accepted systematic characters of certain Mammals," June 9th, 1904, Vol. I. I am still of the opinion that they deserve "Flag rank," though they have not yet been promoted. Be that as it may I think it may be well here to compare two animals belonging to the family Equidæ, the horse and zebra, which resemble one another very closely in form—in respect of these patterns.

Horse and Zebra Compared.

If a horse of the hackney type and a zebra were skinned and the bodies of the two animals then examined I suppose a competent anatomist would find some difficulty in distinguishing one from the other so closely do these two allied species of equidæ, one wild and the other domesticated, resemble one another in structure. But in this as in many other questions *form* is not to be considered alone. The colouration of the two animals is strikingly different, but, in its humble way, the difference of their patterns of hair-arrangement is worthy of notice. The horse in different specimens chosen from a large group will exhibit patterns in the frontal, pectoral and inguinal regions constantly, and variably in less common regions, axillary, cervical and gluteal, that is to say, in six different areas. I have examined many zebras, living and dead, and find no constant pattern in the whole of its large surface of skin except an ill-developed frontal and a very small cervical one—*two in all*. The mere numerical difference is not the only important one, for the insignificance of the size of the two zebra patterns and the constancy and high development of many of those of the horse are not less significant from the present point of view. I submit that these two animals carry about with them on their hairy coats indubitable records of their personal and ancestral habits. Attention to the facts of a horse's life and certain related and contrasted facts of the lives of other animals, of which the zebra may be taken as a type, will show the reasons why these patterns are to be looked upon as registers of long-past and present activities of the species concerned. The horse has been developed out of a wild plastic stock with some such ancestors as the wild horse of Przewalski,

lately brought to Europe, by a process of selection by man during a thousand generations, first in its Central Asian cradle and later all over the civilized world. It has been as much *made by man* for his purposes in locomotion as a locomotive engine has been made by him. The one has been produced in accordance with the laws of applied physics and the other by those of biology. His locomotive life has come to pass for the needs of higher, or at any rate more cunning creatures, who have availed themselves of the potentialities provided by Nature. The zebra in its habits differs from the horse in the simple, but fundamental point that the former lives the ordinary active life of a wild animal for its own needs of protection against foes and search for food, the latter has not only this activity of life in its organisation, but has, super-added to it by domestication, all the locomotive life of a beast of burden. The zebra presents few, if any, of those phenomena which I have often termed Animal Pedometers,¹ so characteristic of the hairy coat of the horse. I am reverting here again to the region of metaphor for which I offer no excuse, but only a few remarks as to the use and value of that elusive method of illustration. Metaphor is a figure of speech or writing which consists in a transference of thought from one idea to another. It is, therefore, not a simple substitution of synonymous expressions, nor is it merely a simile. It is in hourly use in the speech and writing of common as well as highly educated persons, and adds much to the ease of communication among us of our thoughts upon subjects which rise somewhat above the level of mere statement of obvious facts. So long as metaphors are not abused by being used as arguments to prove some proposition, but only as illustrations of our meaning, we gain greatly by their legitimate use. It is not for nothing the well-drilled Press of Germany in their journals and its histrionic Emperor in his rhetorical outbursts, make extensive use of metaphors. We are everlastingly reading of Germany's "biological necessity," her "iron will to victory," the "steel ring of field-grey heroes who guard her against a world of devils," of her "brilliant second," her "granite walls," her "future on the water," the "Admiral of the Atlantic," "grasping the trident," and so on in nearly every public utterance of her leaders. They know well their audience and employ these harmless, if often ridiculous, expressions with a definite and legitimate purpose, and are well qualified for creating the public opinion of a nation that dearly loves a phrase.

Well, this term, Animal Pedometers, is used here not for proving anything, but for the purpose of impressing on the mind of the

¹ *Knowledge*, January, 1903.

reader the fact of certain patterns on the horse's skin being intimately related to its locomotive life which, I hope I may assume, has been sufficiently demonstrated in this chapter. A pedometer is one of those works of men devised for his physical and mental advancement which are marked by a precision as well as purpose often absent from Nature's handiwork. Just as a pedestrian, cyclist, or motorist carries with him his pedometer and tells you with some pride the number of miles he has "done" in a day or hour, so the horse displays *urbé et orbi* his rougher registers of the locomotive triumphs of his ancestors and himself, and these I call Animal Pedometers by way of metaphor, and patterns by way of fact.

The less striking and rarer patterns of the horse's hair have been fully described elsewhere,¹ and it would serve no useful end to refer to them at length, nor to multiply proofs of the position here maintained.

¹ *Direction of Hair in Animals and Man.*

CHAPTER X.

HABITS AND HAIR OF UNGULATES.

Oxen.

THE even-toed section of hoofed animals is a much larger group than the odd-toed, and the difference may be illustrated by looking at the great work on Natural History by Lydekker. There are 273 pages given up to this group and only 112 to the odd-toed, and when we remember that there are contained in it the hippopotamus, all the pigs, oxen, sheep, goats, antelopes, camels, llamas, giraffes and deer, we can see that Lydekker was well justified in the great amount of space devoted to them. But we all have our different forms of *penchant*, and I propose to say very much less about this section than about the other represented by the domestic horse. It is well to claim the shelter of a great name in such an apportionment of interest, and Professor Poulton has given a clear precedent in his great book called *Essays on Evolution*. It contains 393 pages and even though the subject of the work is Evolution, he has given up 330 pages approximately, or five-sixths, of his space to insects. This can be gathered from a rough analysis of his various essays, and no one need blame a great biologist for having a *penchant* for the subject he knows best, or a small one for writing of that he knows a little.

The reason that the even-toed ungulates require less study from the present point of view is that they are so much more marked by the normal or primitive slope of hair than the previous group of Chapter IX. They demonstrate very widely and thoroughly the empire of the primitive or "barbarian" forces and so far are valuable witnesses of the negative kind. No case can well be proved to satisfaction by a large series of negatives, and this was the hopeless task Weismann set out to prove, when he staked his all on the non-inheritance of acquired characters—and failed. But negative evidence is of great value in supporting an hypothesis when it is found to be the precise complement to extensive positive evidence brought in favour of that hypothesis. That is the case in regard to the patterns of hair found on oxen, sheep, antelopes, gazelles and deer, to say nothing of hippopotami, pigs and llamas. There are some of these patterns described in the previous group

which appear in this larger one, but for size, persistence and frequency they cannot be compared to those of the horse, who has, if I may so say, inherited all the family property in his own person and added to it.

The variations in the present group are fully dealt with in the two earlier books already quoted,^{1, 2} and I will not complicate this chapter by any further remarks on them.

Oxen.

Of the numerous divisions of even-toed ungulates the oxen present the best cases for study of the various ways in which the hair is disposed, and among them the best as well as the most accessible is the domestic ox. Again we have a familiar friend of man and innumerable specimens for examination as in the case of the horse. So this chapter will, like the preceding one, resolve itself into the study of one typical animal, with whose habits of life we are intimately acquainted.

Before describing the habits and hair of the domestic ox or cow, I would like to point out why I value so highly the negative evidence which consists in the comparative rarity of whorls, featherings and crests in even-toed ungulates. This brings us back to the general fact of the *raison d'être* of the horse and his group on the one hand, and the ox and his numerous relatives on the other. There are deer, antelopes and gazelles which for a spurt would beat any horse and even the Thibetan wild ass, so I am not trying here to disparage the power of this graceful swift group in the matter of sprinting. But this term, however colloquial it may be, clearly marks off the powers and habits of deer, antelopes and gazelles from those of the horse, for, except when trying to escape from an enemy, no deer, antelope or gazelle is fool enough to sprint or even trot for mere pleasure or want of occupation, and certainly not in the service of man. Thus it comes to pass that animal pedometers are few and small in this second group of ungulates, and I submit this negative fact gives strong support to the views advanced throughout this volume.

A Cow's Habits.

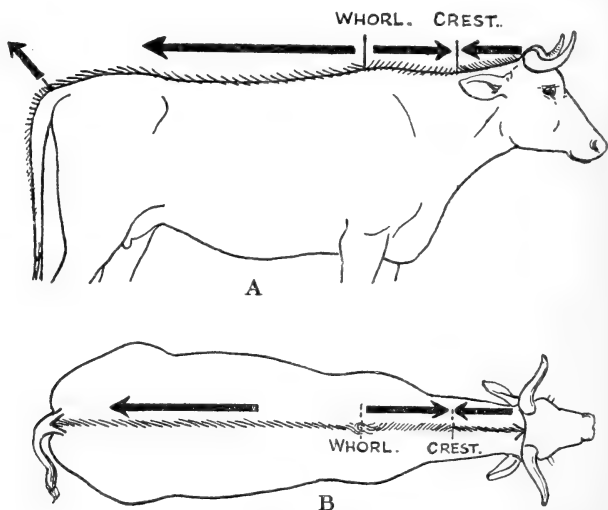
A cow is a very restful animal except when disturbed by extraneous causes, and the active habits of her life are of little interest here, the chief importance of her for study being the passive side of her life or small minor tricks. As a domestic animal she

1 *Op. cit.* *Use inheritance.*

2 *Op. cit.* *Direction of Hair.*

lives to eat—and be eaten and drunk—but her wild ancestors and relatives have had far from an easy life, though this (in them even) has not expressed itself in animal pedometers. But on her neck, back, flanks, legs and haunches the cow has some interesting specimens of areas where the normal hair-slope is reversed in accordance with her habits.

The most striking of these is shown in Figs. 34 and 35, where the bare form of the animal is shown and the dark thick arrows



Figs. 34 and 35.

- (A) Side view of cow, showing arrangement of hair-streams on the back.
 (B) View of back of cow, showing the same.

are made paramount in order to make the remarkable arrangement of her hair along the back so clear, that little verbal description is needed.

Behind the level of the horns the normal or backward slope proceeds until the middle of the length of the neck is reached, when it encounters transversely a sharp upstanding crest and beyond this the hair is directly reversed from a point over the

shoulders, and here a whorl is found. From this point the stream returns to its ancient and normal course and so passes to the tail. When the base of the tail is reached a very significant and apparently whimsical arrangement of the hair down the centre of the tail is observed. This consists in a line of stiff hairs which stand up at right angles to the surface of the tail, and it gradually passes into the normal again when the more muscular part of the tail is passed. I should add here that the crest and reversed hair on the back are common to many wild ungulates of this ruminant group, and a good example of it is seen in an antelope, *Oryx Beisa*, which I figured and described in a paper at the Zoological Society of London.

Arrangements of its hair so audacious as these need explanation, and it is found in the mode of life of the cow. So large a part of its daily life is spent in the business of grazing with her muzzle close to the ground, during which the neck of the animal is constantly stretched downwards from the back at the level of the shoulders, that the skin, which is very loose in this and most other portions of its body, is dragged upon to allow of the extreme flexion of its neck. This traction is for all this time acting against the normal or backward slope of the hairs, and has given rise to this victory of a new force through a thousand generations. It is equally clear that a mechanical explanation of the line of erect hairs on the first nine or twelve inches of the tail is forthcoming, for one has only to watch a cow standing on a hot day, undergoing her torment of flies, to see it writ large. Very strong little muscles are found at the base of the tail, those along the more free portion becoming smaller and smaller until they disappear towards the tip. These give a powerful flicking action to the long heavy tail and I once made some observations as to this on a number of cows which were grazing in summer on a comparatively cool wind-swept hillside in the western end of the Isle of Wight. I watched several cows on different occasions and found that one would flick her tail 348 times and another 1082 times per hour. Giving these cows an eight hours' working day, "working" for their living in grazing and ruminating by turns, one gains a vivid idea of the number of times per diem these powerful muscles of the tail contract. If we call it a day of four hours of grazing and four of ruminating, for the sake of argument, we get 1392 to 4328 flicks of the tail each day in the time of flies, leaving out of account the casual flicks in which she would indulge when flies were not tormenting her. It is hardly necessary to point out how the underlying muscles would drag upon the skin of the tail over them and gradually reverse more or

less the "lie" of the hairs. They have not formed into a feathering or complete reversal, but have come near to it.

Further down the haunches of the cow there is on each side at the back of the thigh a curving reversed area of hair which turns upwards and towards the middle line. This is the place where the tail as it swings from side to side sweeps over the limb and brushes upwards the hair of the thigh towards which it is swinging. So that the activity of the tail is responsible for another of the patterns in which the cow's hair is arranged.

The lower segment of the hind leg exhibits one more reversed area of hair due to the cow's habit of lying on the ground slightly inclined to one side, for the more comfortable disposing of her limbs, the effect of this attitude being seen in the manner in which the hair on the back of the leg turns inwards.

On the dewlaps and flanks are certain variable curls and turns of hair produced by the frequent twitchings of a muscle situated just under the skin called the "Fly Shaker" or *panniculus carnosus*. This muscle is seen any day in the carcase of an ox hanging up in a butcher's shop, and it is interesting to notice the fact that it is distributed over only the lower half of the flank, for the purpose of shaking off flies from a region which the tail does not reach efficiently. None of this sheet of muscle is found within the effective range of the cow's light artillery, as on the haunches or hinder portion of the spine. This sums up the equipment of patterns of hair on the species of this group of ungulates, which is more adorned with them than any I have examined, and it will be admitted that compared with those of the horse, it is a poor exhibition, but one which it is easy to understand if the fundamental principles of this inquiry are kept in mind.

Light Occupations of the Cow.

I watched lately a little act of this drama among a herd of cows on the Stray at Harrogate during a hot day. There were 105 of them and this was what they were doing all day—some were browsing with their muzzles close to the ground, their necks making a considerable angle with the line of their trunks, others standing stock still with their heads raised at a level with the body, gazing vacantly into space, others lying on the grass more advanced in the strenuous work of their day, ruminating with head level, also gazing at nothing in particular, with their bodies gently rolled to one side, their fore legs doubled straight under them and their hind legs planted to one or other side, and a fourth group still nearer the end of the cycle of work, lying with their chins resting

on the ground. When this cycle was completed the stages would again be begun, continued and ended. They were flapping their wide ears in various directions, and twitching endlessly the skin of the flanks and dewlaps with their fly shakers. This large group afforded, if one may so describe it, a cinematographic picture of the lives of countless generations of this conservative animal. Conservative as she is, I doubt not that in the long-past ages her quiet though persistent habits had once a battle to wage for the production of even these mild innovations that I have described. These present fashions must have been well developed three thousand five hundred years ago and have adorned that "calf, tender and good," which Abraham in the plains of Mamre fetched for the midday meal of his visitors.

CHAPTER XI.

HABITS AND HAIR OF CARNIVORES.

Cats.

ANOTHER large and important order of hair-clad mammals must now be considered, and the same course as in the case of the ungulates will be followed; the two leading families of Felidæ and Canidæ will be taken, and a type of each examined in reference to its hair-distribution. Lydekker gives about 100 pages to the cats and 80 to the dogs, so from the point of view of general biology there seems little to choose between them. The bears, racoons, weasel tribe, seals and walruses may be put out of account. They are painfully old-fashioned or Normal as to the arrangement of their hair.

First things first is always a good rule, and there is little doubt where we ought to begin among the families and species Carnivores. Among Felidæ one cannot unfortunately choose the harmless necessary cat of tiles, areas, firesides and ladies' laps, to say nothing of those lovers of cats like Huxley who would never eject his cat from his armchair if she had been there before him. It is true that we know much of her daily and nightly mode of life—many of us too much—and in that respect one could set to work with confidence in interpreting her hair patterns, but on account of her long and thick coat we can only speculate what patterns or innovations of her family uniform she might have devised; but here we are not concerned with romance or the "might have beens." It will be remarked that one perforce unconsciously calls the domestic cat "she" as sailors do their ships. I understand that in Somersetshire they call everything of their common life "he" except the tom-cat who is always "she." The reasons for the use of genders in different creatures would be an interesting little study.

Lion.

The King of Beasts will, therefore, be the hero of this chapter. Lydekker tells us that the lion, like many heroes of antiquity who are no heroes to their valets, in spite of his character for grandeur, nobility and courage, has been subjected to the merciless higher criticism of modern travellers, Selous, Livingstone, and others,

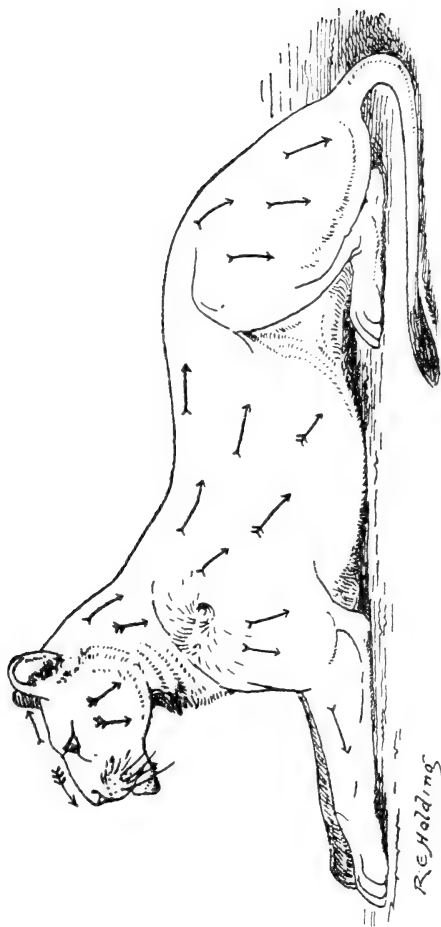


Fig. 36.—Lioness, showing by arrows the direction of hair-streams on muzzle, parting from one another at the level of the orbits.

and he has been shown up as cowardly by nature and mean in his general conduct. It remains for some learned scholar to whitewash the hyæna, as someone has done for Caesar Borgia, and to put him in the place of the lion. But Lydekker does not admit that this disparagement of the lion goes very far. He is the King of Beasts by grandeur of appearance, strength and ferocity.

The lion's skin is covered by close fine hair, except in certain seasons in cold climates, and is easily studied. There are three regions where this representative cat has departed from the Primitive mammalian slope of hair, and the figure of a lioness shows two of these, the peculiar *downward* trend of hair on the muzzle and the whorl on the shoulder. Fig. 37 shows the third, A C, on the middle of the back as well as the whorls at D.

Snout of the Cats

The muzzle of all the cats is very short and broad, and at the level of the orbits shows a peculiar reversal of the hair from the rest of the head, for instead of being like that of a dog in which the hair slopes all the way *upwards* from the tip of the snout to the rest of the head, it breaks away from this normal type and passes in a uniform close stream to the edge of the wet muzzle. The arrows in Fig. 36 show this change. One asks at once the reason for such an unexpected trend of the hair on a small area, when the carnivores in other groups have a uniform slope towards the head from their more pointed muzzles. The cats have discarded the earlier family pattern and for a reason which does credit to their self-respect. Very few naturalists know, or have described so well the meticulous care which animals take of their coats, as Miss Frances Pitt did in the *National Review*, where she gave a delightful account of "How Animals Clean Themselves." The toilet of the lion she did not discuss, perhaps for prudential reasons. Her account dealt chiefly with a number of small hairy mammals and lower forms of life. Watch a dog cleaning his coat and you will see the ingenious way in which he pushes his head and body forward as he lies on some rough surface such as grass, or our best drawing-room mat. *He* can thus clean his snout and other parts, but no cat adopts so rough and ready a method. We know how long and how scrupulously she licks her fur to clean it in the parts she can reach and cleans her head with her paws. But with such a broad snout as she and the larger cats possess she cannot clean the short surface of it in the manner of the dog. So she "dresses" this little surface in a special way of rubbing it from the neighbourhood of her eyes *forward* with her paws. And so we may assume does

the chieftain of her clan finish off this little bit of his toilet. We are so much accustomed to dwell on the naturally clean habits of a domestic cat that without such an account as Miss Frances Pitt has given we should have hesitated to transfer the character for personal cleanliness from the domesticated to the wild cat. If this be not the sole reason for the course of the hair-stream I have described, I am at a loss to imagine any other.

Lion's Neck.

On each side of the lion's neck where it joins the shoulder there is a well-developed whorl, and this as a rule is extended forwards into a feathering (Figs. 36 and 37), and ends in a crest on the lower part of the side of the neck. It is common also in tigers and leopards. This is, as elsewhere, a record of strong and oft-repeated action in powerful muscles which lie beneath it, and bears witness to the great functional activity of the fore-limbs as compared with the hind-limbs in these three formidable cats. It is not an animal pedometer, but may perhaps be termed an *ergograph*.

Lion's Back.

The strange pattern of reversed hair (Fig. 37) is much the most notable of the three peculiarities found on the lion's skin. It consists of a whorl (A) lying over the lumbar region in the middle line which expands into a very broad feathering (B) and terminates in a crest (C) a short distance behind the level of the shoulders. This is not found in any of the numerous short-haired *Felidæ* that I have examined, and it is a feature which demands explanation.

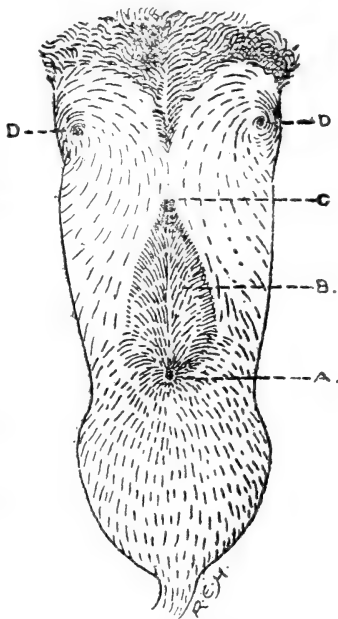


Fig. 37.—Back of Lion, showing reversed area of hair with whorl at A. Feathering B. Crest C.

I know no other mammal, ungulate or carnivore, that has any pattern resembling this ; indeed, if one were to photograph the pattern in question and a few inches of the skin surrounding it, and be told that it came from the back of a mammal one could not doubt that it was a hall-mark of the King of Beasts. It would not produce that thrill of intense interest which we felt at the meeting on 7th May, 1901, at the Zoological Society of London, when from a water colour sketch and three pieces of skin taken from the body of a hitherto unknown mammal, Sir Harry Johnston proceeded to reconstruct the Okapi, at first dubbed knight, as a member of the Equidæ, but later promoted downwards to the Giraffidæ. But one could do no less, with some knowledge of the hair of mammals, than reconstruct from such a photograph a large, powerful and ferocious carnivore, and where but in the lion can the greatest example of those attributes be found ? I say this advisedly, for this remarkable pattern of the lion's back is as much a stamp of his moral or mental quality as the Inguinal Pedometer is of the locomotive rôle in life of *equus caballus*.

I hear the sharp voice of the critic here, "Come, come, you may have shown reason for the latter, but how on earth do mental and moral qualities of an animal come into your scheme ?" Well, we have in this pattern of the lion's back to deal with a unique phenomenon for the production of which neither pressure, nor friction, nor gravitation, nor underlying muscular traction will account. Nevertheless, it is a result of muscular action of a rare kind. Who does not know the striking appearance of the hair along the centre of a short-haired dog when he bristles up with rage or fear, or both combined, at the sight of a foe ? This common event has its own mechanical cause, though it is one strictly governed by the mental and moral qualities of the dog, and we see the vivid proof before us of the action of the minute *arrectores pili*, in this particular region of the dog. It is precisely in the same situation that the special pattern of the lion's hair is found. It is not for nothing that Nature has provided every tiny hair of the mammalian skin with that insignificant little band of muscle which lies within the hair-pit, and is attached to the sloping hair on its posterior side, and thus when it contracts serves to drag it into an erect position. I refrain from discussing what may be held to be the survival value, under the theory of selection, of this power of the *arrectores pili* to confer on the possessor an added appearance of ferocity and general frightfulness. This is quite a likely explanation of the presence of these little muscles. Be that as it may the *modus operandi* of the reversed hair which has become fixed on the lion's

back is made clear, theory of origin apart. And I submit that the presence of it in this region in this animal is a stamp of his persistently ferocious nature, as much as the various peculiarities of arrangement of hair on man's eyebrows in a previous chapter are of the mental and moral habits of the individual man. As rulers of old used, in their genial fashion, to brand a supposed or actual criminal on his shoulder or forehead, so is the lion branded with an hereditary mark of his nature and the past life of himself and his ancestors. I doubt not that if short-haired terriers were living a wild life among numerous foes their bristling hair would have become fixed in a similar fashion. I would only here draw the attention of the reader to the fact that this reversed area of hair on the lion's back cannot be held to add to the general frightfulness of the possessor. It would be invisible to an approaching foe, as it lies hidden behind the great head and mane. This pattern on the lion's back will be referred to later in a somewhat different connection.

CHAPTER XII.

HABITS AND HAIR OF CARNIVORES.

Dogs.

AMONG the canidæ one is able to select a type with whose habits of life we are more familiar than any other, *Canis Familiaris*, as he is affectionately called, the companion of man his master, and faithful guardian—often unto death. Professor Scott Elliott gives reason to think that the dog was the first animal tamed by man, and that he was descended from some wild jackal-like form, probably crossed by the wolf. The dog is then aptly called by Huxley, the brother of the wolf, who has been changed by the intelligence of man into the guardian of the flock. It seems that in his rudimentary stage of domestication he was an unofficial scavenger among the habitations of neolithic man, as the pariah is in the East to-day, and that little acts of kindness towards his offspring on the part of those early men and women were the first dawnings of a friendship of thousands of years. It is a long story from the slinking jackal to the bloodhound, mastiff, St. Bernard, staghound, collie and terrier of to-day, and one which reflects much credit on both parties to this friendship, just as do those other long friendships between servant and master, of which we still see a few examples. Living with us as he does the dog and his habits of life are an open book; he is then all the better for my humble purpose here. I would refer again to the curious use of the gender which we unconsciously apply to the dog. It is no longer “she,” but “he.” When a dog is looking a little unfriendly how we always try to wheedle him with “Poor old fellow,” and so on, as a matter of course, assuming his masculine character. James Payn pointed out once a little point which proves how good a comrade we have in the dog, when he reminds us of the cautious approach we usually make to a cat, and the “hail-fellow-well-met” tone we adopt towards the dog, rolling him over and using kindly opprobrious terms, such as friends among schoolboys hurl at one another when they are on the best of terms. A fox-terrier is, perhaps, the most human of all the numerous types evolved through the skill of man, and it is a smooth-coated specimen of this variety which I will examine now as to what his hairy coat can tell us of his habits.

Some of the Dog's Habits.

His attitudes which bear on this question are all of the passive order. His locomotion is so fitful and different from that of the horse that we shall find on his coat no animal pedometers.



Fig. 38.—Gluteal region of dog, showing whorls over the tuberosities of the ischia.

His passive attitudes consist of standing, sitting and lying. He stands little, sits more, and lies for a great part of each day. The standing habit has, of course, no influence upon his hair. In sitting he rests the chief weight of his body on the rounded, bursa-covered surfaces of his tuberosities of the ischium, in which there is nothing peculiar to himself. His fore legs are planted nearly upright on the ground and his hind legs doubled under him

or projecting slightly to one or other side, as we saw in the case of the cow. The fore legs are obviously in no way affected as to the direction of the hair in the sitting posture, and the hind legs, being doubled up and subject to the direct downward weight of the body, are also free from the *sliding pressure*, which we shall see affects the fore limb when the dog lies prone. Thus of the three supports, fore legs, hind legs and tuberosities of the ischium, two are necessarily unaffected in their patterns of hair. The anatomical conditions of his tuberosities are very different in this respect. They are covered with a large slippery bursa just beneath the thick skin, and the slightest movement of this alert and restless animal, even of his head, conveys to this region a small change of position. He is virtually like a sick person on a water or air cushion, and we all know how very small movements of the body are felt in a slight stirring of the supported parts by these. The effect of this is that the hair over these bursæ is seldom at rest from external or extraneous forces, to say nothing of its own imperious constant growth of one inch in two months. In Fig. 38 one sees the hair-stream curving round the buttocks towards the region of these bursæ, and trying to reach the middle line. It meets with so much opposition that the very conditions for producing a reversed area are present and the result is just what one would expect to find. The pattern is formed exactly over the bursæ limited to this area, and it does not expand anywhere because there is no need for it to do so. So when one observes on the surface just below the tail a pattern, often in a black-and-tan terrier marked by a tan patch of hair, one reads the record of the long time spent by the dog in sitting as he meditates on some fresh or past escapade of "A Dog's Day."

The statement just made that the hind leg does not share in the effects of pressure is not strictly correct; it applies to the *leg* properly so called. But the upper part of the thigh exhibits a very clear reversal of hair due to the weight of the body acting here against the streams from the side of the thigh, which are seen endeavouring to make their way to the inner side. They are arrested by a long ridge of hair which marks the obstacle presented by the weight of the body acting here. This completes the story of the way in which sitting affects the hair of the dog, and is shown in Fig. 38.

Lying Attitude.

There are four attitudes adopted by the dog in lying. In the first, when he sleeps he lies stretched out on his side on

some surface, with his limbs projected nearly straight out, and in the second, he curls himself up in *his* armchair in a cosy, rounded posture. But in both these attitudes there is no such sliding

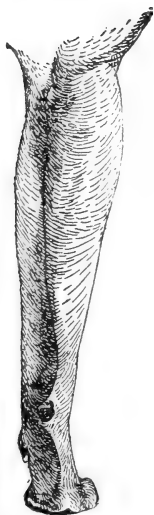


Fig. 39.—Foreleg of domestic dog, showing reversed hair on under surface, which rests on the ground in lying posture.

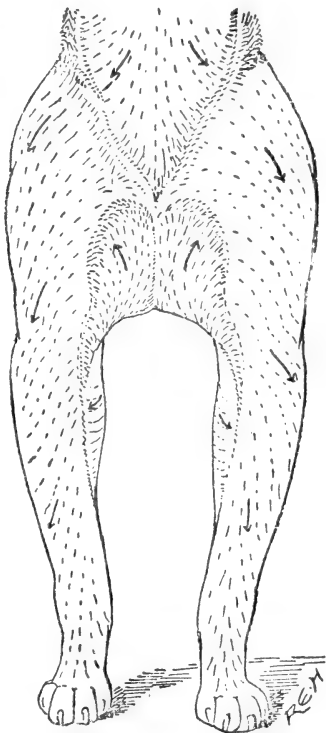


Fig. 40.—Showing chest of domestic dog, with reversed area of hair on each side.

pressure as will affect in any way the direction of his hair. In two other favourite attitudes it is far otherwise. When he lies prone he plants his fore limbs out before his chest and either raises his head to the level of his trunk or rests it on his fore paws. Each

of these attitudes contributes to a very well-marked change of the hair on the under surface of his fore arms, to use a convenient human term, one which carries us back to the story of man and the apes when their fore arms were discussed. On this surface, from the mechanical conditions involved, a new force, that of *sliding pressure*, comes into play. The skin here is very loose, as indeed it is in the greater part of his body, which may almost be said to form one large subcutaneous bursa. The weight of the fore part of his body and head acts *downwards and forwards*, and thus opposes the normal or downward course of the hair on the limb, such as one sees on the upper surface of his fore arm. The resultant of these two forces has the effect of acting against the normal slope, and a reversed direction of the hair is produced very much like that which is seen in many monkeys and in a small area in man. This is shown in Fig. 39, which appeared in the small book¹, to which reference has been made, and it is confined to the part of the limb where the sliding pressure is seen to act. In this feature again there is a record of his resting habits, and, of course, the time he spends in the fourth attitude with his chin resting on his fore paws contributes its share, the mechanical conditions being similar.

This fourth attitude brings in another force of its own towards the "make-up" of the dog's patterns of hair. When lying with his head supported on his paws the lower part of his chest is closely applied to the upper or flexor surface of the fore legs, and the long-continued pressure of the latter against the downward or normal streams of hair on the chest leads to its slope being reversed. This is shown in two wide patterns of the whorl, feathering and crest, Fig. 40, resembling closely the corresponding patterns on the chest of a horse. I had the opportunity many years ago of examining in the Capitol Museum at Rome two fine sculptures of Molossian hounds, when these matters of hair-arrangement were occupying my attention, and was much struck with the fidelity with which the ancient sculptor reproduced such small facts as the reversed areas of hair in a dog. Phiz himself was not more true to Nature in his delineation of the projecting hairs on the human eyebrows. It should be added that the reversed hair in question occupies only that part of the chest which is in contact with the fore limb. If one cannot reckon any animal pedometers, to the credit of the domestic dog I think one may fairly and metaphorically say that his hairy coat gives an accurate mould of his habits.

¹ Use—Inheritance.

CHAPTER XIII.

HABITS AND HAIR OF PRIMATES.

IN spite of the satires of Swift we may not cavil at the natural pride which has led man, *Homo Sapiens*, as he also calls himself, to confer boldly on himself, and his lineal ancestors at any rate, the name of Primates. This large and highest group of hair-clad mammals includes broadly and somewhat loosely lemurs, monkeys, apes and man. The last has not lost his hairy endowment, though it is sadly curtailed, and it is well to remember that, except on the palms of the hands, the soles of the feet and the terminal rows of phalanges of fingers and toes, man is a hair-clad mammal. Shakespeare calls him "paragon of animals," and Huxley "head of the sentient world," and no reasonable person will attempt to improve upon such pregnant tributes to his greatness. I desire only to adhere that *quâ animal* he is the best of all for my humble purpose of historian of the chequered course of the mammalian hair, better even than the domestic horse. His hair varies from a coat so fine as to need a lens for the discovery of the separate hairs, to a truly Simian profusion of thick and long hair such as that of the Ainu or hairy aborigines of Japan.

Hair and Habits of Man.

The streams of his hair demonstrate two important facts about man: first *what he has been*; secondly *what he has done*, that is to say, his ancestry and habits of life, through an immense stretch of time. These stories in hair are the culmination of a large number of characters inherited and acquired, and their study in two selected regions of lemurs, apes and man will be pursued in this chapter on the lines which I laid down in Chapter VI. I have thought it well not to give any connected account of the rest of his hairy covering so as to concentrate attention on the two simplest and most striking regions. The charts of his hair-streams and those of the lemur and ape have been described with sufficient fulness elsewhere,¹ and no cartographer has hitherto sought to improve upon them.

¹ *Direction of Hair in Animals and Man.*

The back and the front surfaces of the trunk afford the two best and most instructive fields of study, for the forces which act upon them are of a simple kind, and may be traced upwards from the lemurs to man as in the case of the forearms. The three drawings (Fig. 41) represent the backs of a lemur, chimpanzee and man, most of the details of the hair being omitted and their place taken by thick dark arrows which show the line of the different hair-streams. This diagrammatic method will make any misunderstanding of the main facts impossible.

The lemur has on the back of its neck a forward or headward slope of hair and this passes on to the head itself, and on the back of the trunk, as the arrows show, there is no departure from the normal arrangement of the lower mammals. The lemur, therefore, requires neither further description nor explanation.

The ape shows no material change in this region from the arrangement of its lemur or monkey ancestor, in spite of the greater proportion of its life which is spent in the upright posture ; indeed, this is what one would expect.

Hair of the Back of Man.

When the hair on the back of man is examined a remarkable change from the patterns of any of his known or supposed ancestors is found. It is by no means easy to trace the course of the hairs on the human back. A young, hairy and dark-haired person gives much the best field, and a lens may be necessary. In older subjects the hair is often so much worn away by friction that the direction can no longer be followed. Suffice it to say that the examination, though somewhat difficult, can well be carried out if the proper conditions are observed ; and that it bears out the results which have come from the corresponding examination of infants. *The arrangement is congenital.*

From the neck the hair passes on each side nearly downwards, and in the middle directly downwards in a narrow stream between the two muscular borders of the vertebral furrows, and continues in this normal direction to the end of the spinal region. It will be seen that below the two upper arrows there are three levels of arrows, the first with one, the second with two, and the third with one, on each side of the surface of the back. At the level of the shoulder-joints the side-streams curve upwards towards the spine and join the central stream ; at the second the direction is rather more upwards before it curves inwards and downwards to the vertebral furrow ; at the third the streams curve slightly upwards and towards the middle-line and coalesce with the other streams.

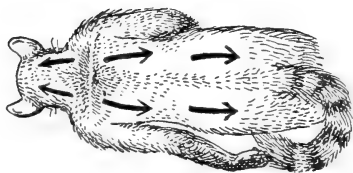
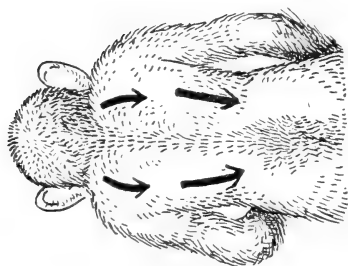
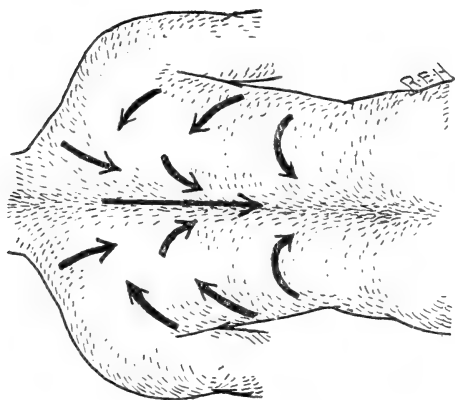


Fig. 41.—Arrangement of hair on the back of lemur—chimpanzee—man.

The contrast between the straight, simple slope of the hair on the lemur's and ape's back, and that of man is very great. In the latter the side-streams make an angle of 45° or less with the axis of the spine and *this arrangement is unique among mammals*. It will be, therefore, necessary to inquire into its history and causation, for it goes far towards reversing the well-established and accredited pattern of apes, monkeys and lemurs. If the reader will carry his mind back to the arrangement of hair on man's forearm he will see that it exhibits some features analogous to those on the back of man. In the forearm there is that curious little stream on the extensor surface which may be looked upon as a relic from the ape-stock, but in the rest of that limb-segment man has boldly gone back, beyond the ape, to an arrangement found in the lemur; and in the case of the back of man there is the small primitive area down the vertebral furrow and an entirely novel arrangement on each side such as might startle the leaders of animal fashions in hair.

The question at once arises: "How has this change come to pass?" In the case of the strange arrangement on man's forearms I have shown that the Pan-Selectionist thought he detected there one of his particular kinds of vestige. He cannot find any such here. I can conceive a biologist making play with Heredity, Variation and Selection in the case of an ape, monkey, or lemur whose hairs are long and thick and functionally very active. *There* he might make use of the well-known "argument from ignorance," and maintain that we cannot be sure that such and such factors might not have survival-value, but I defy the most hardy among the Pan-Selectionist High Command to put in that plea in connection with the fine short hairs of man which even require a lens for their detection; they have little value as a protection of the skin from friction; their arrangement has none. And if some leader did attempt this task I doubt if the most docile Prussian would not rebel against the statement that the withdrawal in question was "according to plan." My purpose, however, in this book being to build up and not to pull down, I must perforce show a reasonable and better explanation of a remarkable little fact.

Passive Habits.

The habits of man concerned in the *modus operandi* of this change are passive, and two in number; that of sitting with his back against some supporting object, and of lying in sleep with his head more or less raised on a pillow or its equivalent. In contrast with man, lemurs and apes inhabit trees during their

many hours of rest, and I doubt if the number of hours thus spent by these and other wild animals to that spent in active exercise is less than three to one, so that their attitudes of rest would, if calculated to do so, contribute much towards any change occurring in the patterns of hair. But, seeing that the ape-fashion is similar to that of the lemur, and that this normal arrangement is calculated only to be confirmed by the action of gravity and the dripping of rain, and that they do not greatly indulge themselves, if at all, in their equivalent for man's armchairs, nothing else would be expected in the hairy covering of their backs than what we find.

The increasing tendency to the upright position in *Eoanthropus Dawsoni* and *Pithecanthropus Erectus* to say nothing of the men of Cromagnon—led man to use as supports for his back the walls of his rough caves which he had adopted as dwellings instead of the branches of trees and the nests of the ape. He no longer affected entirely those hardy habits of sitting without support for his back that were *de rigueur* in his ancestors, who probably looked upon him with as much disapproval as certain erect old ladies of the old school display towards the use of easy chairs by the rising generation. Wearied with the struggle for food, and against his savage rivals, he rested his back against the sides of his rude abode. When he slept in this attitude the relaxation of his voluntary muscles allowed mechanical forces to come into action which tended to oppose the downward trend of the hair. We know from our own experience that when sitting asleep with our backs supported there always occurs a certain amount of sinking down of the trunk. In this attitude are present, then, such conditions of the back and its hairy covering as give rise to mechanical forces which would interfere with the direction of the hair. These are, a heavy body, tending to slip downwards slightly while resting against a fixed surface, a growing tissue easily diverted from its normal course, and many hours spent in the attitude in question.

The effects of these conditions increased with the increasing tendency of developing man to attend to his bodily comfort.

But man spends also on the average at least a third of his whole existence lying in sleep with his head on a pillow of some kind, perhaps the skull of a *Felis Groeneveldtii* in the case of *Pithecanthropus Erectus*, and other such better objects, as he made more study of the art of being comfortable. Those who know much of children and sick persons and have watched them in sleep know that the habit of lying on one or other side prevails largely over that of lying on the back. The head being more or less raised by a pillow, the human sleeper, even when lying on his back and more

so when lying on his side, is in a potentially and actually sliding position, a fact well known to most persons from their own experience. It is easy to see how such conditions are tending for a third of a man's whole life to reverse in some degree the direction of his hair and how they act as we saw in the case of the sitting posture. But the very common *lateral* position in sleep contributes its own peculiar share in pushing the hair towards the spine, ceasing to do so only when the prominent muscular border of the vertebral furrow is reached. I think it will escape no careful observer of these simple facts of man's resting life, who also notes the remarkable course of the arrows on his back, that the facts and their present explanation fit one another like a Chubb lock and its key. The only alternative suggestion of the facts is that some being with diabolic power has been at work and laying a trap for poor human biologists in the 20th century A.D.

In confirmation of this process I would refer to an example which agrees very closely with the above explanation. I knew an invalid suffering from pleurisy and lung-disease who was much confined to bed, spending much of his time propped high up on pillows. He had long dark hair on his back and I was often struck, when examining him, with the remarkable way in which the hairs were dragged upon so that they pointed nearly in a vertical *upward* direction. Here was a little instance of an undesigned experiment in the dynamics of hair.

Hair of the Chest.

In the hair-streams on the chest of our chosen three, lemur, ape and man, there are also some remarkable contrasts in the course they take. Fig. 42 shows these in a vivid manner. Precisely as in the case of the hair on the backs of lemurs, apes and man, we find on the chest of those three types a normal direction on the two lower ancestors and an entirely novel arrangement in man; the former, therefore, will need no verbal description.

Man, the ever bold explorer and innovator has initiated on his chest, as on his back, a fashion in hair unknown in any of the primates. He is, in respect of his hair on these two regions, *sui generis*. On the chest there is a critical area extending across the sternum at the level of the second rib from a whorl which is found on each side somewhat above the nipples. This is not less an ancient battle-field than the Border which separated England and Scotland, and it has been the site of its little conflicts, more especially *north* of the Border, corresponding to those of the wild days of Border warfare of which Scottish history is full.

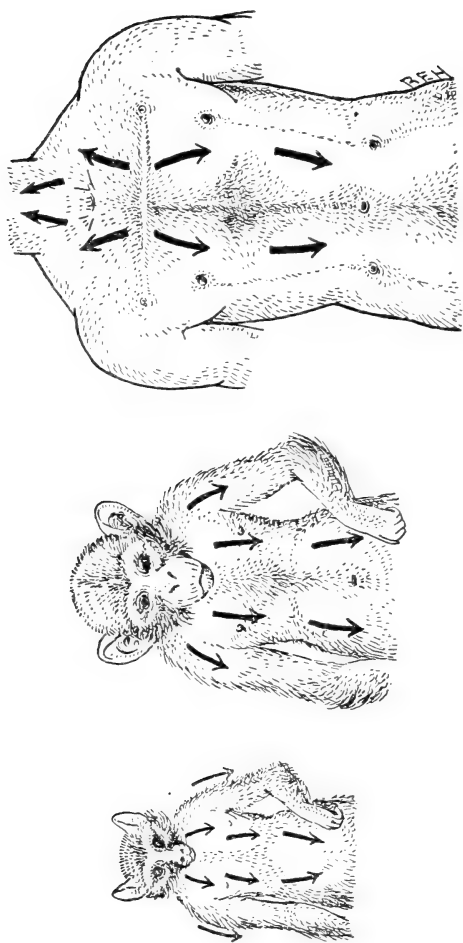


Fig. 42.—Arrangement of hair on the chest of lemur—chimpanzee—man.

At this level of the chest two streams of hair are *directly* opposed to one another. That which covers the chest below the dividing line maintains in true old English style its conservative fashion and passes downwards as in the ape and lemur. The more independent or Scottish stream goes upwards on its way to the neck, the side streams passing somewhat outwards towards the side of the neck, the central upwards and inwards, converging gently on to the front of the neck. The arrows in the figure show this very clearly. On the front of the neck the stream pursues its upward way until it meets the downward flowing stream from the lower jaw, and the *junction* of these two streams lies over the level of the upper border of the larynx in front, winding gently outwards and upwards to the surface just below the lobes of the ears. The opposition of the two streams in the neck is very familiar, as a piece of practical experience, to those who shave, for it affords a decided little resistance to the razor as it is drawn downwards, and many persons change the position of the razor in consequence of it, without troubling their heads with any scientific reason for the fact.

These are the facts of the distribution of hair on man's chest, but what is the interpretation? I would remark here that in my former book¹ I gave what seemed to be then the best reason for it, but further reflection on the matter has shown me that it was incorrect and inadequate. I refer to this and one or two other corrections of earlier views in a later chapter.

Interpretation of Records.

In discussing such a striking little fact as the one in question, an illustration may serve as an introduction. From the glaciers of Mont St. Gothard two great rivers take their rise. The eastern side of its slopes gives rise to the Rhine, which flows in a northerly direction to the Lake of Constance, the western to the Rhone, whence it pursues a south-westerly course to the Lake of Geneva. No geographer would doubt that certain physical features of the country were to be sought in accounting for the contrary courses of two rivers arising from a comparatively small region, and he finds it by a simple study of the topography concerned. By similar methods we must ascertain why from our little Mont St. Gothard at the level of the second rib, two streams of hair separate and pursue nearly opposite directions.

A little knowledge of the superficial anatomy of the chest and neck throws some light at once on the problem. It so happens

¹ *Direction of Hair*, pp. 88-93.

that if one made a simple map of these hair streams, and at the side of it a drawing of the platysma myoides muscle, it could not fail to strike one that the correspondence of the surfaces occupied by the two phenomena was very significant. It is going too far to say that the correspondence is complete, but it is so nearly so that one may fairly say that the reversed stream of hair which begins at the second rib and goes up the neck, lies over the platysma muscle. The stream of hair does not extend up to the lower part of the face and lower jaw, it does not cover the outlying portion of the platysma on the side of the neck and it begins on the chest a little above the rather uncertain origin of the platysma fibres from the fascia of the chest. But the correspondence of its surface with the main part, or about five-sixths of the platysma, is most suggestive.

This muscle is one of the subdermal sheets that are found in many mammals, and though it is not a continuation or descendant of the fly-shaker or panniculus carnosus, which is often referred to in these pages, it is an analogous feature of man. It is *closely attached* at its lower part to the skin over it and more loosely at its upper. It has various functions attributed to it, as I will mention later; but there is one effect of its action which is very evident in a thin person, that is to say, it wrinkles the skin over it in a vertical direction. This it does, whatever else it may do.

Struggles of the Platysma.

In interpreting this novel hair stream of man's chest and neck we are again brought into an atmosphere of struggle of forces. Something has occurred in the course of man's descent from the ape to interfere very sharply with the course of the hair; and certainly if there be anything in organisms that Heredity, Variation and Selection are unable to do (even when adorned with capital letters, to make them, as Huxley said, "like grenadiers with bearskins," appear much finer fellows than they are), it is to provide in this reversed stream of hair on man's chest some cunning "adaptation" to his needs. Selection will not serve; but I think use and habit will. There can be little, if any, doubt that the frequent and active contractions of the platysma muscle in the course of man's life are the efficient cause of the change of arrangement of hair from a downward simian to an upward human slope. To this opinion the anatomist will promptly reply: "Ah! I have thee there, friend Lamarckian; are there not any number of apes and monkeys that also have an active and efficient platysma?" Undoubtedly there are, and I give here, through the kindness of

Professor Keith, a short account of that muscle in *simiadæ*. It is taken from an unpublished work of his on *The Myology of the Catarrhini—a Study in Evolution*. The account may be only interesting to the professed anatomist, but the conclusions in the summary bear closely on the present problem. I give the exact words from Chapter II., pp. 472, 479. The simian forms examined are *semnopithecus*, *gorilla*, *chimpanzee*, *orang*, *gibbon*, *macacus*, *cercopithecus*, *cynocephali*. “Summary: Every gradation is found between the cynocephalic and human forms. The evolution lies in the disappearance of the supra-trapezial origin and the superficial labio-mental insertion. The opposite nuchal and mental angles of a trapezoidal sheet are obliterated and a rhomboidal figure is left. The change may be seen step by step through the *macaci*, *semnopithecus*, *hylobates*, *troglodytes* and the *orang* to Man.

“The maxillary insertion in man is more extensive than the others, and the insertion is more distinctly demarcated from the quadratus menti origin. But slips between the two muscles are not uncommon.

“The sub-mental interdigitation occurs frequently in man, and although its extent varies in the other Catarrhini it is always present.

“The upper nuchal fibres, being cut loose in the higher members of the orthorachitral group from their primary origin, became aberrant in their behaviour. Auriculo-labial slips, slips of union with the zygomatici, or simulating a *risorius*, or a relapse to the primitive medial dorsal origin and connection with the occipito-auricular muscles may occur in man as in the others.

“Fasciculation of the muscle may occur in man and the *troglodytes*.

“That the functions of this muscle are indefinite is shown by the numerous individual and generic variations. But that its presence is essential may be judged by its persistence. It may depress the angle of the mouth or the lower jaw, or help to flex the head upon the chest, or help to empty the laryngeal air-sac if it be present. But as a matter of fact all these functions are otherwise provided for. When tense it protects the deep part of the neck somewhat, and it is usually active in temper. The axillary part of the same sheet in the *cynomorphæ* offers a similar puzzle as regards its functions.”

We have it thus on the highest authority that the platysma muscle is active and persistent in a large series of monkeys, apes and man. But the whole work has for its sub-title, “A Study in Evolution,” and in the story of the platysma there is a picture of

its progressive development to that of man. There is evidence in the above account of the muscle that a structure is found in monkeys and man which might operate on the overlying streams of hair in any of these animal forms—or might not—in accordance with the conception of struggle between opposing forces which I have kept in view all through this volume.

It is evident that in all animals below man the platysma has not achieved any victory by its action over the streams of hair on the chest and neck, and to my mind it is equally evident that in the case of man it has carried through a very manifest "turning-movement." It will be objected, quite properly, that this is a matter of opinion, and the pertinent question will be asked, "How do you account for the absence of this reversed hair-pattern in apes and monkeys and its absence in man, both having an efficient platysma muscle?"

The essence of a struggle is that it ends with the victory of one adversary over the other, and as the race is not always to the swift nor the battle to the strong, there is of necessity some uncertainty as to the result of any struggle. The factors of time as well as of overwhelming force are required for most of the victories of man over man, and it is not less so in the victories of habit over ancestry in the direction of hair, as I have repeatedly shown. The required time is clearly at one's disposal for this victory, and the "overwhelming force" of habit and use is purely a question of the degree of repetition and the efficiency of the contractions of the platysma, and its greater use in man than in apes and monkeys. The uses to which it was put in the lower forms not having been sufficiently overwhelming for victory, no change in them has been shown. The cumulative effects of the actions of a developing platysma in man, under the guiding influence of his more complex habits of life, have turned the scale in favour of the reinforced forces of habit, and the direction of the hair becomes reversed nearly all over the area covering the muscle.

We must consider all the forces engaged in this struggle for mastery on the neck and chest of man, and remember on one hand the power of the normal slope of hair, the greater difficulty of altering the direction of the thick long hairs of monkeys and apes, and their relatively long resting hours; and on the other the shorter and finer hairs of man and the increasing efficiency of his platysma muscle in varied actions. Professor Keith mentions four functions of the platysma: that of *depressing the angle of the mouth and lower jaw, helping to flex the head upon the chest, and to empty the laryngeal air-sac, and protecting the deep parts of the neck*

when it is tense—adding the significant comment that “it is usually active in temper”—I presume this to mean bad temper!

Leaving out of account the emptying of the laryngeal air-sac, is it not evident that the remaining three actions of the platysma are very much more exerted in the case of man with all the numerous occupations and movements of his head and neck, in obedience to his higher brain, than in the apes, monkeys and lemurs, endowed with a fitful activity, with fewer and less variable movements of their head, and long, long hours spent in their particular form of meditation?

So, when the muscular sheet, which, as I have said, is *closely attached to the skin of the chest and more loosely to that of the neck*, contracts and becomes shortened between its origin on the chest to its insertion in the face and jaw, it gives a most obvious pull on the skin over it and wrinkles it vertically in a manner which will strike any thin person who contracts it voluntarily before a looking-glass. The connection shown between the action of the platysma muscle and the change of hair is so close that it can hardly be questioned that one is the cause of the other. If it be not proved to demonstration it is “tremendously probable” and the connection falls into line with the previous demonstrated cases.

I must add here a remark suggested by the views of man's descent put forward since this was written. The claim that man has changed the direction of his hair on his back and chest by use and habit owing to altered modes of life is not dependent on the simian theory of his descent. The change to his present patterns on those two regions from those of any “active arboreal pioneer” among insectivores is just as striking and is open to the same line of explanation.

It would serve no useful purpose here to travel further over the varied streams of hair on the body of man.

CHAPTER XIV.

MISCELLANEOUS EXAMPLES.

IN this chapter a few of the rarer examples of hair-clad mammals which present remarkable changes at critical areas of their hairy coats may be considered with advantage. I have chosen six, of which three appeared in my former book.

The Giraffe.

The two drawings of a giraffe, Figs. 43 and 44 were made for me for the purpose of illustrating one of its habits and two of its peculiarities of arrangement of its hair. This stately creature is the tallest known animal and is the sole representative of its ancient family, more common in the days when giants abounded. Its range is becoming more limited and its enemies not less dangerous, and it is expected in the course of some years to add to the number of the recently-extinct creatures.

Habits.

Living mainly in dry sandy regions giraffes find their food exclusively in leaves plucked from trees, and are said by some authorities to exist for a long period without drinking, but an interesting account quoted by Lydekker from Selous should be mentioned here. Selous writes that on a certain occasion he reached camp "a little before sundown, just in time to see three tall, graceful giraffes issue from the forest a little distance beyond, and stalk across the intervening flat, swishing their long tails to and fro, on their way down to the water. It is a curious sight to watch these long-legged animals drinking, and one that I have had several opportunities of enjoying. Though their necks are long, they are not sufficiently so to enable them to reach the water without straddling their legs wide apart. In doing this, they sometimes place one foot in front, and the other as far back as possible, and then by a series of little jerks widen the distance between the two, until they succeed in getting their mouths down to the water; sometimes they sprawl their legs out sideways in a similar manner." Lydekker adds that this position has to be

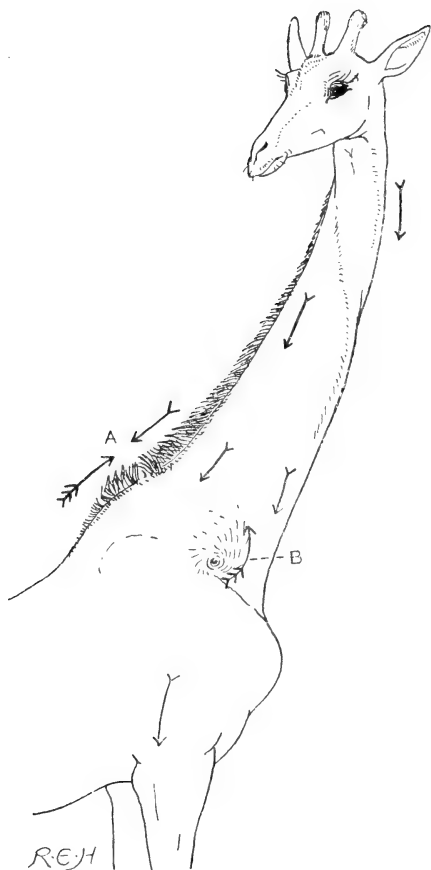


Fig. 43.—Giraffe showing at A and B, hair-patterns of a remarkable kind at the place where the main movements of the neck occur.

assumed not only when drinking, but likewise when the animal desires to pick up a leaf from the ground or on the rare occasions when it grazes. This habit so graphically described is the one which alone concerns my subject. The patterns of hair peculiar to the giraffe need a short description.

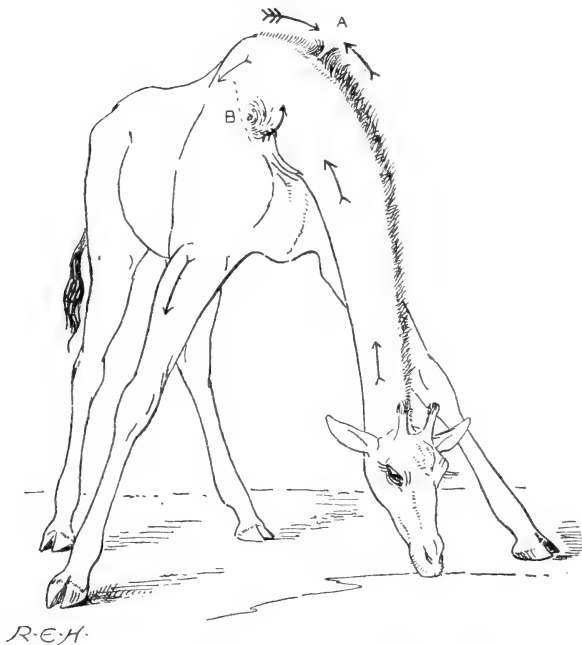


Fig. 44.—Giraffe in the act of drinking or browsing off the ground.

Hair Patterns.

Fig. 43 shows a whorl (B) at the side of the neck on a level with the prominent spines of the seventh cervical and first dorsal vertebrae. It lies exactly over a spot which may be well called a "critical area," for an important hinge of the whole mechanism of the giraffe's great neck is situated here. Though the remarkable length of its neck is intimately associated with its daily needs for

protection against enemies and the supply of food from high-placed branches of trees, it forms a real obstacle to the less important need of obtaining water to drink or food from the ground as Selous and Lydekker show. The protective value of the neck is picturesquely described by Mr. Beddard when he speaks of it as the giraffe's watch-tower, whence its keen eyesight surveys the surrounding country for its enemies. But its attitude in drinking, Fig. 44, gives a vivid idea of the play of forces which takes place at the great hinge between the neck and the trunk, and at this point the whorl has been produced on the skin in the course of its laborious efforts to supply itself with water. The absence of any other whorl or reversed hair on the whole of its neck and trunk is most significant from the point of view of the dynamics of hair.

The second departure from the normal direction of hair is found on the prominent portion of the spine, and it lies over this hinge-area. In Fig. 44 is shown the mane proceeding along the whole of the neck in the normal downward direction, and the arrows indicate the way in which it becomes suddenly reversed at the critical point and the lowest portion of the mane stands up and points upwards. This change is shown by the two arrows whose points meet one another, and the facts of its occurrence, here and nowhere else, at once suggest that the habit which produced the whorl on the side of the neck has also contributed to the change in the direction of the mane. The pattern here is precisely of the same order as that of the cow's neck which we saw to be caused by its habit of browsing off the ground.

Bongo—*Tragelaphus euryceros*.

This West African antelope is a forest-dwelling species, about which little is known as to its habit of life, though its form and anatomy are well described by Lydekker. It has a powerful chest, long and strong horns, and short hoofs, and it is shown in Fig. 45 with its large pectoral whorl, feathering and crest, in which it strongly resembles the domestic horse. One may be allowed here, as exact knowledge is wanting, to point out that "reconstruction" of its habits may be reasonably attempted along the lines laid down in these pages. It is doubtful if any large mammal could possess so powerful a fore-end with very muscular forelimbs, highly-developed pectoral patterns and short strong hoofs without being a very fleet animal much accustomed to relying upon its speed for its protection, and if a greater knowledge of it be obtained in the future it is highly probable that this prediction will be verified. Part of its habitat is described as the Ashkankolu Mountains, a region where speed would be of great value.

Kiang—Thibetan Wild Ass.

This member of the Equidæ is shown in Fig. 46 and there is an excellent specimen of it at South Kensington. I have chosen it because it is very unusual among others of its family in the possession of an inguinal and axillary whorl, feathering and crest. No other than the domestic horse that I have examined shows these patterns. They are nearly as well developed as in the horse, and require no special description. It lives in high altitudes up to fourteen thousand feet, and travels often in large herds, its food being composed of the various woody plants of these dry and barren regions. Lydekker says that it "is remarkable for its fleetness and its capacity for getting over rough and stony ground at a great pace." From these facts one can gather that a large portion of its working day would be spent in rapid locomotion from place to place in search of its sparse food-supplies and in avoiding enemies—two paramount objects of its existence which are pictured in the two animal pedometers displayed on its hairy coat

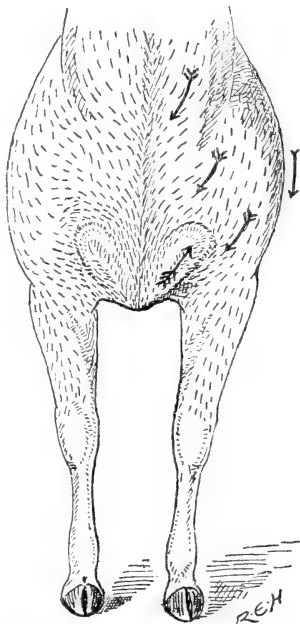


Fig. 45.—Bongo. Showing on the strong muscular chest, well-formed pectoral patterns.

Llama—L.

I refer here to the true llama or domesticated form of the genus Llama, of which the vicunha and huanaco are the existing wild species. In the stirring time when a handful of Spanish Conquistadores under Pizarro conquered and trampled upon the ancient civilisation of the Incas this useful animal was employed to an immense extent as a beast of burden. Lydekker says that at the time of the Conquest of Peru it was estimated that three

hundred thousand llamas were employed in the mines of Potosi alone. Prescott gives an excellent account of the use of this animal in his *Conquest of Peru*. They were valued highly for their strength and sureness of foot which were much needed in their long and rugged journeys over the great passes of the Cordilleras, as well as for the excellence of their flesh.

The only region of a llama's body which is of interest in the present inquiry is the fore-foot, figured in Fig. 47. It presents a very remarkable arrangement of hair on its under surface, just above the double hoof and spongy pad at the joint above the hoof. This is found on each side towards the outer border of the hollow region, and consists of a whorl from which the hairs radiate in a reversed direction towards the upper part and transversely across the rest of the hollow. Prescott speaks of "its spongy hoof, armed with a claw or pointed talon to enable it to secure hold on the ice," and adds that "it never requires to be shod." If one reflects upon the ceaseless action during rough and slippery locomotion of this animal throughout its working life on mountain passes, on rough stony paths and ice-covered places, one can have no doubt of the reason why this particular joint, so greatly used in maintaining a foothold, should have acquired on this sheltered portion of its hair an animal pedometer.

The Parti-coloured Bear—*Æluropus Melanoleucus*.

This is a rare and peculiar form of the family of Ursidæ about which I made a statement some years ago at the Zoological Society of London. It is a "stocky" animal with a small head and broad short muzzle, a feature to which it has no right according to its affinities. It is not a member of the high-class Felidæ whose special prerogative it is to wear their hair on a short broad muzzle in a downward direction as I showed in Chapter XI. Being a more *bourgeois* creature than a cat it has offended against such sumptuary laws as may exist in the animal kingdom.

Its hair ought to be worn in the proper backward or upward slope such as other bears, dogs and small carnivores display.

In my former note I modestly proposed an alternative suggestion to the one I now offer, of this aberrant and strange bit of hair-country, and this was that it was correlated with the broad short snout. As I have remarked before this word "correlated" is used so loosely as to mean almost anything the user likes, and it is, in my opinion, a fine source of confusion of thought. Undoubtedly this shape of the muzzle of the Parti-coloured Bear is linked somehow with the arrangement of its hair on that region. But it is

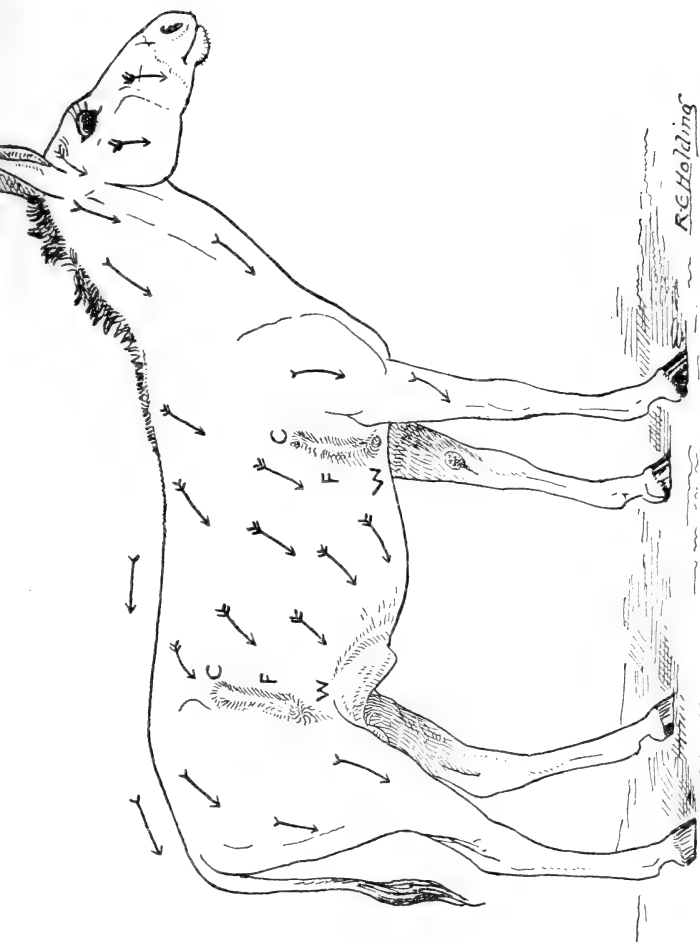


Fig. 46.—Kiang. Side view showing inguinal (W F C) and axillary (W F C) patterns.

hardly to be imagined that a direct reversal of hair from the proper bear-type, that is to say from the mouth to the head, would be produced by the mere broadening of the muzzle on account of some adaptation to its altering life. The link surely is of a different nature, and analogous to that of the corresponding surface in the lion and other cats, and that the cleaning of its fur on the snout is done in feline and not

in ursine fashion, that is to say forwards, and that the breadth of muzzle is the reason for the change of method.

Two-Toed Sloth— *Cholæpus didactylus*.

This weird creature is one of a decaying family whom naturalists, with needless and frank brutality, called toothless. The term is neither exact nor polite. It is very much as if one were to call a person

"toothless" whose front teeth had been knocked out, but whose remaining teeth were good and useful. But it represents so important a taxonomic character that one must allow for what seems bad manners on the part of zoological leaders who are, as a rule, full of the milk of human kindness, and seldom in these days quarrel even among themselves, adopting the motto *nihil animalium alienum a me puto*.

The sloths form an excellent example of the action of gravity upon long thick hairs, and the Fig. 48 given will explain this. They are New World animals, though indeed they have what we call an

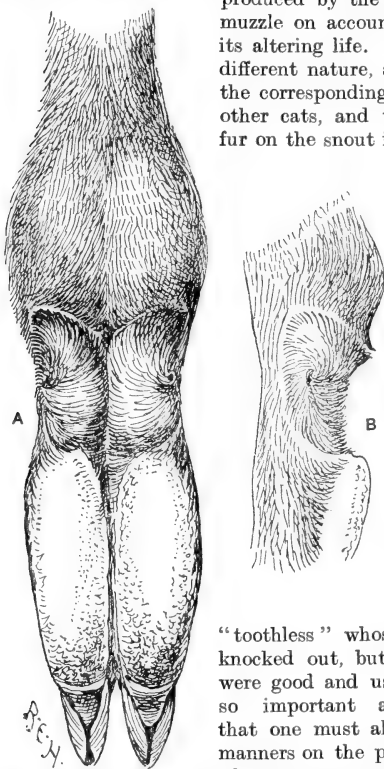


Fig. 47.—Fore foot of llama shown from behind (A) and from side (B) with whorls of hair and reversed areas on each side.

“ Old World ” look, and are truly ancient. They spend the larger part of their time upside down in the manner represented in the drawings. They are arboreal and nocturnal animals that come down to earth in search of food when things are quieter below, and will wander for considerable distances, walking slowly on the outer borders of their feet and the feet turned in.

These being the few facts of their lives which concern the present subject one comes, as usual, to interpretation. These tree-sloths are descended from an older form that inhabited the ground,

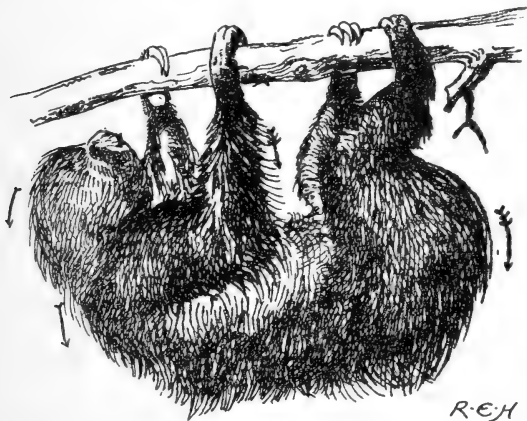


Fig. 48.—Two-toed sloth, showing action of gravity upon the long thick hairs.

so that the present mode of life, which is so largely arboreal, has been acquired by dint of long years of struggle and adaptation to bitter needs. It seems hardly reasonable to call in the aid of selection for the production of its singular disposition of hair though that factor ruled in the production of its arboreal habit. It is almost flying in the face of common sense to attribute this upward, or downward (according to one's point of view) singular arrangement to anything but the effects of gravity upon its long hairs. If it be not so, it looks a remarkable likely solution of this small problem.

CHAPTER XV.

EXPERIMENTAL.

ABOUT ten years ago I began an investigation into the results of the application by man to the domestic horse of various forms of harness, desiring to find out if these results were capable of being transmitted from one generation to another. In 1908 I had not got very far, but thought it well to bring before the Zoological Society of London the results observed up to that time and read a paper entitled, "Some observations on the effects of Pressure upon the Direction of Hair in Mammals." It was kindly received, but was not published in their proceedings, as it appeared to the Publication Committee a paper more suited to "another place," presumably those of a veterinary society. It was illustrated by the two figures I give here of a horse in full harness, and another with the chief results as to changes of the direction of hair, or new patterns, displayed on its coat.

Progress of Inquiry.

Being disposed to think that the investigation could be carried further, I proceeded to look about for any examples in horses which might show the transmission of these artificial results to their descendants, and had to wait awhile before I could see which of the regions affected by the pressure of harness were likely to afford the required phenomena. These were in due time forthcoming, and will form the chief subject of the present chapter. I look upon them as cases of an *undesigned experiment* and will describe them later.

In the present stage of science all hypotheses must be submitted to the test of experiment before they can enter the charmed circle of natural laws. For this reason one must endeavour to apply the test of experiment to the hypothesis before us.

The Nature of Experiment.

Hitherto I have gone no further than the region of experience and observation, from which, Jevons says, "all knowledge proceeds." There has been abundance of observation of phenomena in this

quest and I have ventured even on hypothesis. Experiment is shortly defined by Jevons as *observation plus alteration of conditions*. He points out that when we make an experiment we more or less influence the events which we observe, as when we bring together certain substances under various conditions of temperature, pressure, electric disturbance or chemical action and so on, and then record the changes observed ; and, that experiment may be of two kinds, experiments of simple fact and experiments of quantity. It is unnecessary here to describe all the rigorous rules that the man of science so rightly imposes upon himself before he claims to have proved his hypothesis, merely adding that among others he requires, Exclusion of Indifferent Circumstances, Simplification of Experiments, Removal of Usual Conditions, Removal of Interference of Unsuspected Conditions, Blind or Test Experiments, Negative Results of Experiment, and he lays down the limits of experiment. Those who have not for themselves investigated some scientific problem may learn from this statement some of the difficulties of the work of scientific men and will not fail to respect and admire the caution, patience and honesty of the scientific worker, and will perhaps feel the more gratitude to a class of men by whose self-denying labours they live and move and have their being in a modern state, and by whose discoveries, thus established, they are frequently preserved from premature death.

Experiments for the Present Purpose.

Now in the matter of experiment for the proof of the thesis that changes in the habits of an animal *cause* the changes observed in their hair, it is at once seen that, *ex hypothesi*, no one can impose and work with such calculated conditions as are ordained by experiment, strictly so-called. The action of a habit is a slow process and the movement of a hair is slow ; moreover the lifetime of a man is too short and that of a horse, for example, too long to allow of any individual experimenter applying artificial pressure through many generations of horses, so as to be able to verify his assertion that the effects of artificial pressure do what is claimed, and that these effects are transmitted from one generation of horses to another. One can conceive a calculated experiment of the kind made with numerous individual rats, and successive generations, but it is hardly likely that effectual pressure could be applied to the hairy coats of such small and elusive mammals as would serve to test the hypothesis.

Undesigned Experiments.

We are thrown back, then, on such experiments as may be provided for us by the uncalculated operations of man through many ages. This class I call undesigned experiments and have had more to say about numerous examples of these in another place.¹ Using the term experiment broadly we see many occurrences which consist in an accidental observation of a fact, and Jevons mentions five of these which have led to organised results in science—the double refraction in Iceland spar by Erasmus Bartholinus, the twitching of a frog's leg under stimuli by Galvani, the light reflected from distant windows with a double-refracting substance by Malus, the form of a vertebra by Oken, and the peculiar appearance of a solution of quinine by Sir John Herschel. But he notes something further than this, that is, the way in which astronomers make the earth's orbit the basis of a well-arranged *natural experiment*. He says further that "Nature has made no experiment at all for us within historical times" among animals living in a state of nature, allowing at the same time that man has made an approach to experiment in his domestication of many animals. Huxley himself kept an open mind until the last as to the validity of Natural Selection in the *Origin of Species*, because of the fact that races which are sterile together have not yet been produced by human cultivation, for example, the sterility of mules, the human product of the jackass and the mare. I allude to this to show that such a result, if effected, would have constituted a valuable experiment in biology in favour of Natural Selection.

Harness on Horses.

Man has, however, been carrying on unconsciously throughout a great stretch of time an experiment upon the hair on the coat of a horse by the use of harness. This is an old story and its rudiments are mentioned by Professor Scott Elliott.² He states that the men of Cromagnon are believed by a high authority as to their rock-paintings to have depicted some marks which represent rude harness of some kind, though he himself expresses doubt on the matter. He also quotes the same authority for the figures made by the Madelenians as having found signs which can be interpreted as halters or even bridles. Be this as it may, we need not carry our search for the use of harness to this hoary antiquity, but know well from history that for many thousands of years man has

¹ *Contemporary Review*, June 1917.

² *Prehistoric Man and His Story*. G. F. Scott Elliott, 1916, pp. 169, 206.

been employing harness on his friend and servant, thus making the essential conditions for an experiment of which he and his servant were alike unconscious, that is to say, he influenced a growing living structure, the horse's hair, by the artificial force of pressure, applied to the coat at various points. These varied from age to age as to fashion and material, and the present full development of harness of a draught horse was probably slow in coming.

Examples of the Effects of Pressure.

Looking at the figures of a horse harnessed, and another without harness, Figs. 49 and 50, one sees on the latter eight different regions where patterns of hair, not found in the horse normally, are displayed. They are as follows:—

- | | |
|--|-------------------------------------|
| A. The under surface of the neck. | Pattern due to the collar. |
| B. The hamstring region. | Pattern due to the kicking strap. |
| C. The hollow corresponding to what we should call the armpit. | Pattern due to strap of saddle. |
| D. The coccygeal or tail-region. | Pattern due to the crupper. |
| E. The side of the neck. | Pattern due to the reins. |
| F. The shoulder. | Pattern due to the shaft. |
| G. The side of the face. | Pattern due to strap of head stall. |
| H. The border of the neck <i>under</i> the collar. | Pattern due to collar. |

All these aberrations from the normal are rare except the first (A), and all are based on the observation and drawing of individual specimens which I brought before the Zoological Society and the details of which are given in a note on page 130. The rarer seven examples are described because taken together they show what the pressure of harness *can* do at certain points where its pressure is adequate, and they are all situated where they might be expected if such a force could effect hair-changes, and there are *none of them found on areas where neither pressure nor underlying muscular traction can act efficiently*. Thus in many thousands of horses I have never seen a hair-pattern on the middle of the flank or the under surface of the abdomen or the middle of the back or gluteal region or on the fore or hind legs. This negative evidence is of great importance, and must be taken for what it is worth. I may venture to remind the reader that every one of these phenomena is an artificial product of man's treatment of the horse. They come thus under the category of undesigned experiments.

The only one of the eight artificial patterns, which as a rule are in the form of a whorl feathering and crest, that needs, further close attention is the pattern A, produced on the under surface

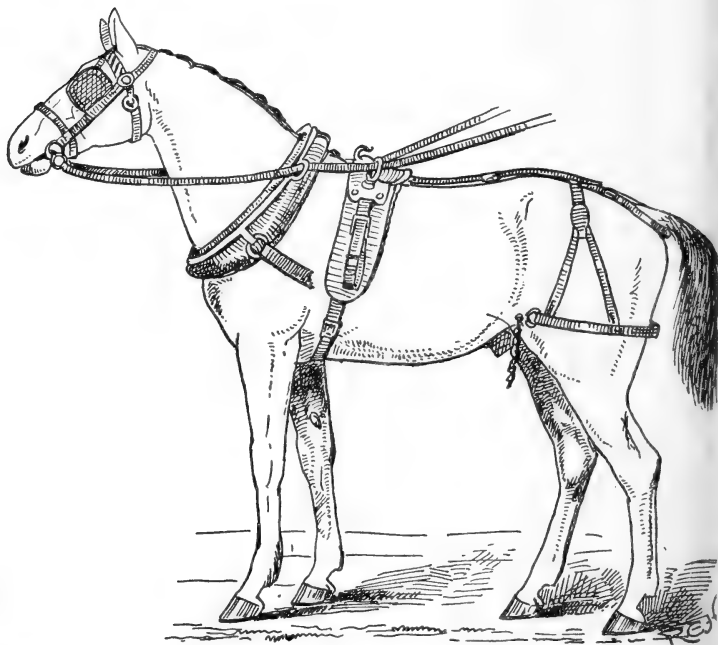


Fig. 49.—Domestic horse, fully harnessed.

of the horse's neck by the collar, and this will be examined separately.

The Selected Example—Ventral Surface of Horse's Neck.

If I set out to convince a doubting opponent that these things are as I assert, three conditions may at once be laid down. First, it must be shown that the patterns found here are not part of a

normal arrangement. Second, that they are produced by pressure of the harness. Third, that examples of them be forthcoming in young horses never exposed to the action of harness.

First. The normal arrangement of hair on the under surface of the horse's neck shows an even stream passing from the head to

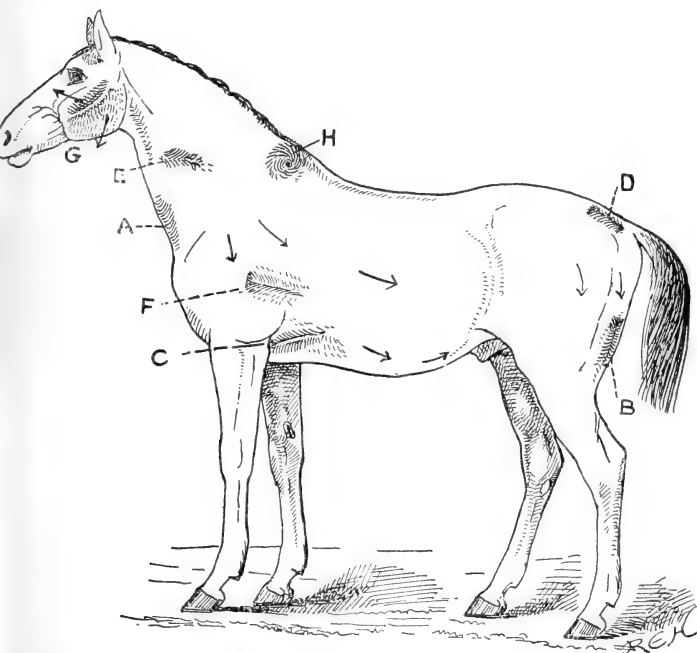


Fig. 50.—Side view of domestic horse, showing eight areas of reversed hair, A, B, C, D, E, F, G, H, all of which were situated under portions of the harness.

the chest, where it is interrupted by the pectoral patterns, and during that course resembles precisely the other normal streams in this and other mammals.

The opponent asks, "How do you know this is the normal slope, and that the patterns you describe are not normal, and what you describe as normal is not a variation?" This is a perfectly

proper and timely question and can only be answered fully by examination of and noting a large number of draught horses.

The Normal Arrangement on the Ventral Surface of the Horse's Neck.

This examination has been made in a number of specimens large enough to satisfy the most exacting opponent. In all, 748 were examined as to the hair on the under surface of the neck and 338 of these presented the normal arrangement and 411 showed patterns of various kinds ranging from a trifling reversed area two to three inches long on one side of the middle line, to a finely-formed whorl, feathering and crest occupying the whole of the surface where

Fig. 50—B. Pattern on hamstring region, under the breeching.

- Examined 24th December, 1907. Roan hackney, recently clipped, showed on the offside on the hamstring region, a reversed area of hair proceeding vertically upwards and ending in a crest, in the position where the breeching rubs during locomotion. Thirteen cases examined, other twelve similar.
- C. Pattern on lower axillary region, under belly-band.
Examined 4th March, 1907. Small grey hackney with reversed area of hair in lower axillary region, with also a crest nearly horizontal lying along upper part of this area under the belly-band. Eight cases examined, the other seven similar.
- D. Pattern on tail region.
Examined 29th November, 1907. Bay hackney, on each side of base of tail where the crupper rubs during locomotion, is a wide reversed area of hair five to six inches long, in which the hairs were arranged at a right angle with the axis of the spine on the upper border and feathering out on the lower border into the general stream of hair. Three cases examined, two others similar.
- E. Pattern on side of neck under the position of the reins.
Examined 21st December, 1907. Small mouse-coloured hackney recently clipped. On the offside of the neck where the reins rubbed against the neck there was a wide reversed area of hair with a well-marked crest in front. Five cases in all examined, the four others similar.
- F. Pattern on shoulder.
Examined 15th September, 1905. Bay cart-horse, reversed area lying nearly horizontal under the shaft of the cart; hairs formed into a whorl, feathering and crest lying posteriorly—pattern four inches in length, on near side only. One case only examined.
- G. Pattern on side of face.
Examined 25th May, 1905. Grey hackney with wide reversed area of hair along side of face ending above in oblique crest, under a strap of the headstall, on the offside only. Two cases examined, the other similar.
- H. Pattern on border of the neck under the collar.
Examined 28th September, 1906. Bay cart-horse. On near side under the collar which was lifted up while the horse was resting, the hairs at the border of the neck were formed into a large whorl. One case only examined.

the collar is able to reach. These two limits are shown side by side in the figures. I should add that among the 411 which I term abnormal, for the sake of clear contrast, the number of varieties of pattern were numerous and bewildering.

Cart Horses.

A very significant result followed from a special examination of 300 cart horses, as distinguished from hackneys. These showed the astonishing number of 277 specimens of what I call the abnormal and only 23 of the normal type. This special group in no way weakens the force of the larger study of 748, for the 300 cart horses are included in it, and, if removed, would have left the normal specimens in the hackney or general group very much more numerous. Looking at the cart horses, which are specimens of a highly-specialised breed for heavy draught purposes, one may assert with some confidence that, *for them*, the normal pattern of the hackney is becoming their abnormal. It must be remembered that these great creatures with large muscular necks are during most of their time of work pulling hard against the collar, and the very conditions required for making patterns of hair through pressure of harness are present in a remarkable degree. It is indeed an *undesigned experiment within an experiment*.

Analogy.

In addition to these statistics which may be taken as conclusive on this question of the normal arrangement, I must point out that it is against all reason, and analogy from *all other* mammals, to doubt that the normal arrangement is as I describe it. No hair-clad mammal either within the family of the Equidæ, or without, has any other arrangement on the under surface of its neck than what is here shown to be the normal one—a uniform uninterrupted slope from the head to the chest. There is also a feature of this greatly variegated piece of the horse's coat under its neck, and that is that it is so highly variegated with diversity of pattern as to make it unlike any normal or natural structure or character in any animal. *That* is not the way Nature does her normal work. It would be impossible to give illustrations of many of the patterns here found, though I have notes and sketches of a large number taken from the examination of thousands of specimens; so I have selected eight (Figs. 51, 52, 53, 54, 55, 56, 57 and 58) of the best representatives of these and the details of each are given under each figure.

Effects of Pressure by Harness.

Second.—The next stage of the inquiry demands that one should show the patterns to be due to pressure.

In the accompanying drawings the under surface of the neck and the chest of each horse is shown with the collar in place, the

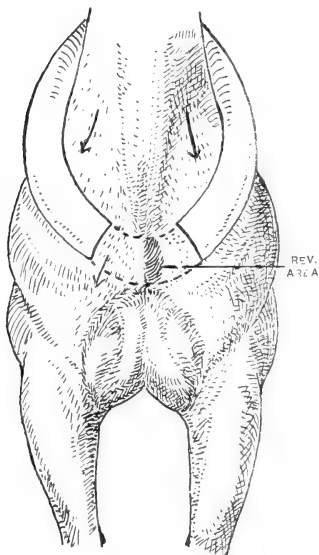


Fig. 51.—Roan cart horse, examined 25th September, 1914. On left side of middle line of the under surface of the neck a short reversed area three inches long, lying vertically—none on the right side.

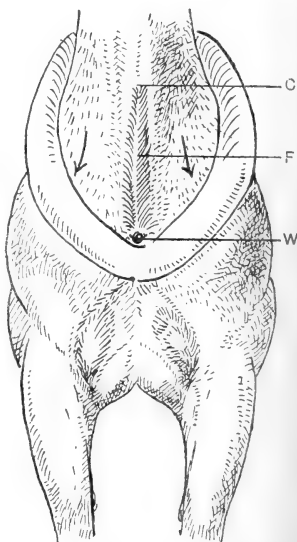


Fig. 52.—Grey cart horse examined 25th September, 1914. Long central feathering (F) proceeding vertically upwards in middle line of neck from whorl (W) and ending in a crest (C) at the upper limit of region, through which the collar can move in active locomotion.

centre portion of which is cut out so as to show the arrangement of hair beneath, and some of the varieties are seen to extend for several inches above it. In considering this process one ought to watch the way in which the collar of a horse, as a rule, is seen to move up and down as he trots, for in most cases, except in cart-horses, the collar fits very loosely and is easily jolted upwards.

This will explain why the patterns often extend upwards above the proper position of the collar, but it must also be remembered that *never* have I found a pattern higher up in the middle of the neck than a loose collar can reach when jolted. (Close to the lower jaw there is a whorl or pattern often found which belongs

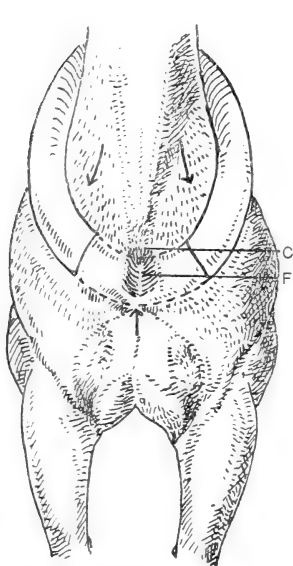


Fig. 53.—Brown hackney, examined 9th October, 1914. Small reversed area of hair lying under collar in middle line of under surface of neck, passing vertically upwards three inches long, in central position.

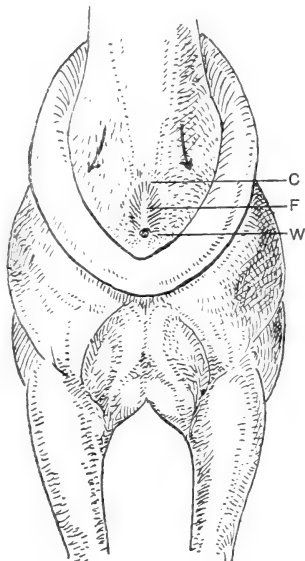


Fig. 54.—Brown cart horse, examined 25th October, 1914. Whorl, feathering and crest (W F C) in middle line of under surface of neck, beginning below where the collar should lie in usual position.

to a different category, and is not to be confused with the patterns in question.)

In the conditions described there is present exactly that frequent pressure of a moving body against the growing hair, which is requisite to produce changes in its direction, as well as the more fixed pressure of the collar when it is fitting firmly against the lower part of the neck.

By way of confirmation of the view that this is the *modus operandi* one has only to point to the other seven regions shown in Figs. 49 and 50, in which the connection between the pressure of harness and the production of a new pattern is beyond all doubt one of cause and effect.

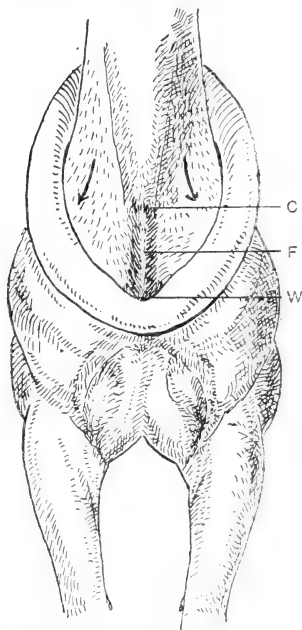


Fig. 55.—Brown cart horse, examined 25th October, 1914. Whorl, feathering and crest (W F C) in middle line of under surface of neck beginning underneath collar and proceeding vertically upwards for six inches.

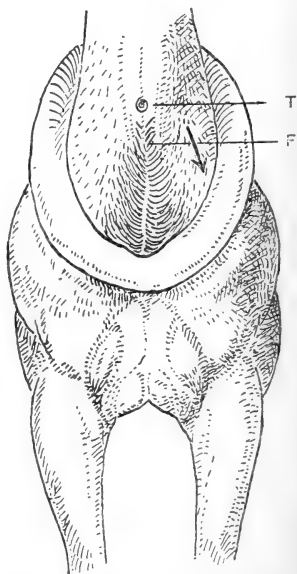


Fig. 56.—Bright bay pony, examined 29th October, 1914. Very muscular neck. On under surface on each side a wide curving stream of hair passing towards middle line and joining in a central upward stream ending above in a tuft (T).

The Proof of Transmission of Pattern.

Third.—To show that the effects produced by pressure in one generation are sometimes inherited by its descendants it is necessary to examine a few examples of young horses who have never borne the yoke as yet.

I examined some mares of the farm-horse type with their foals in a field at Radley in 1915 with the following results. All the mothers showed the common reversed area or pattern on the under

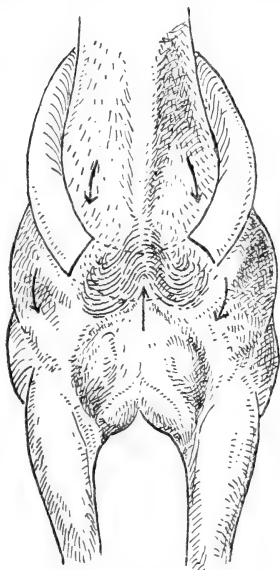


Fig. 57.—Brown hackney, examined 29th October, 1914. On under surface of neck beneath the lowest portion of an ill-fitting collar, a wide area of reversed hair on each side coalescing in a central upward stream.

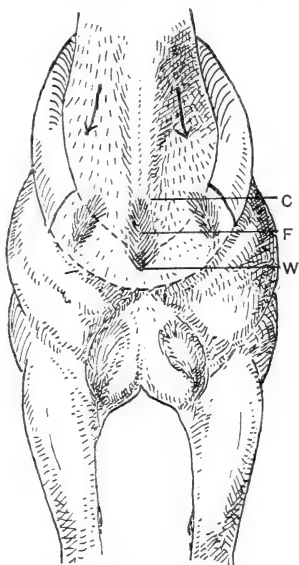


Fig. 58.—Brown hackney engaged in drawing a low Swiss cart, with loose collar low on neck. Examined at the Croix in Jura mountains, 24th September, 1912. On lower surface of neck under the collar three reversed areas observed; one central (F) two (W, C) central and similar; all three showing a whorl, feathering and crest: central area placed vertically, lateral ones slightly oblique. *A very rare condition.*

surfaces of their necks. Of the five foals all but one showed clear evidence, even in their thick young coats, of a similar pattern, the fifth had none. I also noted two similar examples in a field at Harrogate in the same year and both the mothers and the foals showed the usual pattern; and again at Radley in 1918 four more

foals, one of them 24 hours old, who all showed this reversed area. Here then are ten examples of undoubted transmission of the effects of pressure by harness in subjects so young as to be still suckled by their dams, and, of course, never themselves touched by such pressure. I submit that even one such unmistakable example would be enough to prove the case, and that the necessary conditions of a rigorous undesigned experiment by man have been fulfilled.

Objections.

At the end of this chapter which concludes the facts of the case I think it may serve to make the position a little clearer if I state objections which have been or might be raised.

It will not escape the mind of any person who has followed critically this process of inquiry, that in Chapter VII, where the immense variety of the patterns found on the side of the horse's neck are described, there is an apparent resemblance between them and those on the ventral or under surface of the neck. The former were shown to be due to natural forces, those of sustained and repeated underlying muscular traction of muscles and jolting of the neck in locomotion ; whereas in this chapter a considerable number of patterns have been brought forward and pictured on the under surface, and these are attributed to artificial pressure from harness. The reasonable objection is raised, " Why should the former be considered natural and the latter artificial in their origin ? "

The answer to this is supplied by a consideration of the muscles shown in the two contrasted regions. In Figs. 3, 4 and 5, the muscles of the side of the neck are shown to be remarkably *strong and numerous* (in three layers), and *diverging in their directions*. In the muscles of the under surface of the neck of the horse, see Fig. 12, the muscles of the two sides shown are nearly parallel and no conflict of opposing or diverging muscles can well take place in this "debateable land." If there were much divergent or opposing action going on it would, of course, produce the effects on the hair towards the *upper* part of the neck, where the muscles tend to diverge more and more as they pass to the head, and I have stated above that not a single instance in many thousands of horses has been found above the level where a loose collar ceases to rub when jolted upwards. This is very conclusive on the matter of diverging or opposing muscular action.

Then again the jolting in locomotion, which, in the case of the side of the neck is probably more effectual in producing changes of hair than even muscular traction, is almost absent from the under

surfaces, as can be learned from careful watching of the motion of a horse.

Another reason which meets this objection very fully is that I have shown that 300 cart horses presented 277 of their number with reversed areas of patterns in the middle line of the under surface of the neck and these thick-necked animals are just those in which the collar is closely applied to the front of the neck in their heavy draught work, thus rubbing almost incessantly against the lie of the hair. In the thinner necks of the hackneys there are comparatively few indeed of the patterns found here and their collars as a rule fit very loosely and badly, and these frequently show a jolting up and down *clear of the neck*, which is seldom if ever present in a well-formed cart horse.

Further proof of this is shown by the simple fact that it is *under the collar and within its range of movement* that the changes of hair are produced.

No artificial pressure such as that of a collar is exerted on the parts of the side of the neck where the patterns are found ; so I would submit that these two selected and much-disturbed areas owe their hair-patterns to two wholly different forms of mechanical cause.

I referred in the Preface to an important criticism of my earlier book on *The Direction of Hair in Animals and Man*, and will now treat this in some degree of detail. It is from the pen of an eminent American biologist, then Miss IREZ L. WHIPPLE,¹ now Mrs. Wilder Harris, and it is a careful, independent and thoughtful contribution from one who by her studies in this field and in the study of the mammalian palm and sole is widely known, and as widely respected.

Miss Whipple refers on page 403 to certain whorls and featherings on the backs of the lion, ox, giraffe and larger antelopes, which I then attributed to the action of the *panniculus carnosus* in shaking off flies. I am free to confess that the action then invoked by me was inadequate and incorrect and the explanations now given of them in Chapters X. and XI. on the ox and the lion, I think, are less open to criticism.

Again on page 404 she mentions the view formerly expressed as to the cause of the reversal of hair on the chest of man. This, also, I have reconsidered fully in Chapter XIII. where the action of the platysma muscle is held to be the cause of that remarkable reversal.

On page 403 the mistake I made in calling the reversed area

¹ *Science*, 23rd September, 1904. New York.

over the ischial tuberosity of the ischium in a dog a whorl is pointed out. This is corrected in Chapter VI. on the Dogs.

These three are the only errors of any importance that I acknowledge at once. A certain number of minor points are questioned in the Review, and the theoretical portion is strongly criticised. It would be irrelevant to the main purpose of a book which is limited to the subject of Habit and Hair Direction in Animals to introduce some of the more debateable branches of the subject of the former book, such as tufts, the direction of the hair on the mole, the classification of the hair-streams of the mammalian body into primitive, those modified by morphological change, and those due to use and habit. This last is a very wide subject and is far beyond the present limits.

I freely make another acknowledgment. The whole of the subject of the Direction of Hair in Animals and Man was taken up *ad hoc*, that is to say, for the purpose of testing the unpopular doctrine of Lamarckism. If this be an offence against the highest spirit of science, I can but accept the charge with a sigh, and go on, "faint yet pursuing." There is consolation in finding that increased study of a subject is bringing order out of chaos, even if the field be small and the immediate crop poor.

The following are some of the objections raised to the theoretical part of the book :—

The most serious charge against my interpretation of the mode of formation of patterns (whorls and tufts) is that there is a lack of harmony between my preliminary statement that whorls are due to motor or muscular causes and a subsequent explanation of some of them as due to external pressure. I did not state then as clearly as I do now in many passages in the present chapters that for pattern production there may be at least four causes : *friction, pressure, gravity, underlying muscular traction*, and that whorls and featherings may, of course, arise from some other external force acting on the hair at the decisive point of struggle, just as well as from the more common cause—muscular traction on the skin. I think in this region of the Review and where she deals with Selection, she shows signs of that scientific monism which is still affecting many of our great biologists, that is to say, they desire a world-empire in evolution for the great factor of Selection, and will stretch their arguments considerably to save its face. This is shown in the Review on page 406 where a very thin plea is put in on behalf of adaptation and Selection in regard to hair-directions, as in man's minute hairs, which cannot be seriously maintained. That earth is stopped !

Darwin's open-minded dualism in this matter of the factors of evolution appeals to me at any rate more than the jealous attitude of Weismann and his eminent adherents.

Miss Whipple is less determined than I am in claiming for Selection the cause of the primitive slope of hair in mammals. It is the only conceivable arrangement that could exist for the advantage of the primitive forms in their simple life, and is, I submit, as much a matter of adaptation to needs governed by Selection as the possession of a dermal covering itself.

One more point, which, I think, is a small one and a fair one to raise, is worthy of a few remarks. Miss Whipple states that before variations in hair-direction can be logically attributed to external forces (giving the instance of the human scalp) "it should be shown that a change in the direction of the external, more or less wiry portion of the hair produces a change in the direction of the follicle." As it happens, this change is easily seen in the case of the reversed hairs of the human forearm, if the hair be dark and the skin thin. The essence of the theory that dragging on the skin by muscular traction causes the hair to change its direction is that the relatively important portion within the hair-pit is pulled here or there according to the incidence of the prevailing force. But it is, to my mind, very clear that much repeated friction or pressure or gravity acting on the external and longer portion of the hair must, in course of time, drag the portion buried in the skin with it and so change its direction. These two portions of a hair cannot be arbitrarily separated. Shortly, one may say that the push of a force is as evident as the pull. A similar change in the direction of the buried part of a tree-trunk from a prevailing wind can be traced.

The last point is that I "omit to explain the mechanical process by which divergent muscular action could affect hair-direction." This is well answered in the chapter on "Can muscular action in the individual change the direction of the hair?" for there it is shown by numerous examples in the human eyebrow that the muscles underneath the hairs which are embedded in the true skin for a tangible depth, *do* play havoc with the normal arrangement of hair, as the conflict proceeds, the resultant "pull" being actually engraved, signed and sealed by physiological wrinkles of the forehead and face.

CHAPTER XVI.

FIRST SUMMARY.

A LARGE body of facts and an adequate proportion of reasoning have been brought together in the preceding chapters. As far as I understand the proceedings in a court of law, the business of arriving at results or, as they are there called, verdicts, consists in collecting as many as possible of the facts which bear on the case, these are sifted and verified, or the reverse, a certain reasoning on them is carried on ; on this the verdict rests. This case before the court is of a civil, not a criminal nature, and it is a claim made to a certain *derelict property*, that is to say, the honour of forming patterns on the hair of animals, claimed by Use and Habit. The facts concerned have never been disputed, possibly because they were not thought worth the trouble, but they have the singular merit of being open to almost any educated person for confirmation or correction, and the reasoning is certainly not profound, though I think it is cogent. In seeking a result in such a cause, or verdict, one claimant might content himself with an arrest of judgment, another that judgment should go by default, and a third would claim proof. It is with the last I desire to stand.

In one word the claim is that of causation.

Now no one can deny that between the groups of phenomena, habits and hair-patterns there is an evident relation ; but the question may still arise, "What is the link between them ?" I have just said that the facts are unquestioned : substantially they are unquestionable, and they are open to the charge that they belong to the dust-heaps of science, that they are, biologically speaking, such as used to engage the attention of Nicodemus Boffin. Perhaps they are. Of course if they were just collected haphazard and treated like a big collection of little shells in a cabinet, without reference to their natural order, they would possess no evidential value even if they were pretty, for so long as a natural fact remains without its suited interpretation, so long it belongs not to science. Hear Jevons : "Whatever is, is, and no natural fact is unworthy of study for the purpose of its interpretation."¹ Hear also Sir E.

¹ Jevons, *Principles of Science*, p. 269.

Ray Lankester: "That only is entitled to the name of science which can be described as knowledge of causes or knowledge of the order of Nature."¹ Fortified by the authority of a great logician and a great biologist I proceed to claim proof of causation. The stages of the case may be summed up as follows:

1. It has been shown that during the lifetime of an individual, muscular action can change the direction of the hair. Chapter VIII.
2. Undesigned experiment has shown that changes in the direction of the hair, mechanically produced in the individual, are sometimes transmitted to the descendants. Chapter XV.
3. In all the selected examples adequate and ascertainable causes have been demonstrated.
4. The changes of hair described, with hardly an exception, cannot be conceived as resulting from the factors of organic evolution—heredity, variation, adaptation and selection—indeed no serious attempt has been made to connect them in any way with utility.

Causation.

For my sins, the most obvious of which is that I made an unfortunate choice of my first birthday, I had to learn up the dreary pages of Mill's *Logic* and those of other philosophers, for the pleasure of taking a medical degree, and was reduced to that orthodox state of mind in which one was forbidden to suppose that, in the world around where common men and women, every day and all day, are tracing causes for the occurrences they see on every hand, there was anything at work which could be truly called a cause. It was but natural to fall into the nihilism of the Mill and Karl Pearson school. Having neither the knowledge nor the hardihood to discern that their bewildering notions of causation could be gainsaid, I had to remain submissive and as much contented as possible with their views of an elusive subject. This state of passive resistance was not relieved until I had the great advantage of reading a valuable book by the late Dr. Mercier on Causation, which seems to have let some fresh air into the musty doctrines of the orthodox and autocratic philosophers. No one who has read this work can doubt that after all there *is* such a process as causation,

¹ E. Ray Lankester. *Advancement of Science*, p. 7.

and that to find a cause for events is not merely a pursuit of the vulgar, but a duty of scientific persons.

Mill appears to have given eighteen different accounts of causation and to have contradicted himself over and over again in his works dealing with this puzzle, devised mainly by Hume and himself; and his successors, such as Dr. Mc'Taggart, the Hon. Bertrand Russell of "Dog Fight" fame, Mr. Welton and Prof. Karl Pearson, have only got as far as to reduce the number of his definitions and put his views into more modern, but equally misleading terms. Without any disparagement of their other claims to respect and admiration, one may venture to throw overboard this school of philosophers when considering causation, and one may walk and talk in a clearer atmosphere.

The subjects here considered are cause, effect, result, reason, evidence and proof, and all can be seen to enter into my small thesis. They may then be defined, according to Dr. Mercier, as follows :—

1. A cause is an action, or cessation of action, connected with a sequent change or accompanying unchange, in the thing acted on, or more shortly for my purpose *a cause is an action upon a thing.*
2. An effect is a change connected with a preceding action.
3. In reference to causation a reason means the cause of an unchange.
4. A result is the changed state that is left when an effect has been produced.
5. Evidence is of three kinds : evidence of sense, evidence of reason and evidence of hearsay.
6. Proof is evidence inconsistent with an alternative to the assertion.

I turn now to the aid given to the case before the jury, and must show how Dr. Mercier's definitions establish it.

The cause of the changes described is the action of certain new habits on a living growing structure of the mammalian body.

The effect is the change connected with the preceding change of habit.

The result is the changed direction of hair, in other words, new patterns, left when the new habits have been produced, and have been long enough in operation.

The reason for the unchanges observed in many instances is the primitive force of the normal direction of growth of the hair.

The proof of the thesis is that the changes described in the hair—the evidence—is inconsistent with an alternative assertion.

To Some Critics.

It may save time and trouble if replies are given in anticipation to certain classes of critics. I refer of course to those who are well-informed in their branch of knowledge.

To those of high authority and learning, those who ride on white asses and that sit in judgment, who may seek to throw the case into chancery, saying, "This will never do, it contradicts current biological opinion." I can only meekly reply that current or orthodox opinion is frequently wrong, or (shall I say) seldom right, and that the history of human thought is strewn with examples which may justify my impertinent reply.

To another who says, "I daresay you are right in your claim, but there are too many metaphors," I would suggest that, so long as metaphors are not used as arguments, the more metaphors—within limits—the clearer the meaning of the statement.

To him who grudgingly allows, "I think you have proved your case—but what does it prove?" I reply that it proves what it set out to prove, no more and no less, and it is an integral part of proof of a larger claim. And if he further grumble that these matters have no interest for him, one may ask him to live and let live. "What have I now done in comparison of you, is not the gleanings of your grapes of great Ephraim better than the vintage of this little Abiezer?"

To the man who reads the preface and the headings of the chapters, glances at the illustrations, detects one split infinitive, two misspellings and three errors of punctuation, goes home to tea and writes his opinion—it may suffice to remind him of "that curious mental state which looks past problems without seeing them."

I will conclude this section with a parable.

In the year 1788 Arthur Young in his travels through France visited the desolate region of the Landes. "Wastes, wastes, wastes!" was his lament over neglected Brittany, and no less could he say of the Landes, at that time a miserable tract of low ground, bordering the Bay of Biscay. Plantations, the sinking of wells, drainage and irrigation began to fix the unstable sands, making fruitful the marsh, creating a healthful climate and a fertile soil. Early in the 19th century the land here was sold *au son de la voix*, that is to say, the accepted standard of measurement was *the compass of the human lungs*. The stretch of ground reached

by a man's voice sold for a few francs. Crops replaced the scanty herbage of the salt marsh, and a familiar characteristic of the landscape, the shepherd on stilts, was seen no more. Six hundred thousand hectares of Landes planted with sea pines produced resin to the annual value of fifteen million francs, and through these trees also was achieved a climatic revolution, and it is this district which is now a department of a great and well-ordered State.¹

¹ From Arthur Young's *Travels in France during the years 1788, 1789*, with introduction by M. Betham Edwards.

CHAPTER XVII.

VARIETIES OF EPIDERMIS.

PASSING now to the smaller trenches of the front line I have chosen as the first of them a small study of the varieties of epidermis found in mammals. With the exception of aquatic mammals so few of this, the greatest vertebrate class, are not clothed with hair that it is only on the comparatively hairless body of man, with its third of a million fine hairs, that the varieties of epidermis can be broadly studied. Much of this chapter will resolve itself into a consideration of the palmar and plantar surfaces of certain mammals, where no hairy covering obscures the operation of stimulus and response.

I assume that the foregoing phenomena of hair-direction have chosen and raised on his shield their own king. But here I must ask of the succeeding groups when they say, "I am, Sir, under the King, in some authority," the question, "Under which King, Bezonian, speak or die"—

Shall it be Darwin's Personal Selection ?

Roux's Cellular or Histonal Selection ?

Wallace's and Romanes' Sexual Selection ?

Weismann's Germinal Selection ?

The rule of Mendel ?

Selection of mutations according to de Vries ?

Or shall it be the barbarian king *Plasto-diēthēsis* ?

Which indeed of the seven kings will they choose, if I may thus personify them ? I may, perhaps, urge on them the mild and tolerant rule of Lamarck and Darwin rather than that of the other anointed sovereigns, hoping this cannot be taken as an attempt to influence the jury through the Press in a case which is still *sub judice*.

Stimuli and Response.

The skin over the trunk and limbs of man is exposed to stimuli of pressure, friction, heat, cold and wind in very different degrees, according to the part which it covers. I do not here refer to nocuous, or so-called *noci-cipient* stimuli, as being too casual in their incidence for the question in hand. Broadly the ventral surface of the neck

and trunk differ much, in respect of the qualities of their epidermis, from the dorsal. The skin over the former is softer, thinner and more flexible than the latter, which is in adult life thick, hard and with larger openings of the sebaceous glands. As the two main layers of the skin are so closely united it is impossible to state any general rule as to the parts played in this manufacture by the epidermis and dermis respectively. Altogether the skin from the dorsal surfaces of mammals provides a much denser fabric than the latter, and different qualities of leather are obtained from different regions. Corresponding differences of texture are found on the extensor and flexor surfaces of the limbs, especially on the hands and feet. In the course of his long evolution from a hairy stock, whether simian as we thought yesterday, or a lower one as Professor Woods Jones suggests to-day, these dorsal surfaces of neck, trunk and extensor surfaces of limbs have been exposed through countless generations of men to vastly more stimuli of friction, pressure, and response, than those of the ventral and flexor regions. As man's hairy covering diminished, through some mysterious and at present unrecognised cause, these stimuli became increasingly potent in producing a tissue denser than that of the more protected ventral parts where all forms of these stimuli are slight. I do not claim that this was a phenomenon that began with man, for in a measure it was present in those forms which preceded him, and in many related mammals under the cover of their hairy covering.

When we remember, or conceive what a large portion of each of his 24-hours even in his earliest form throughout life man must have spent, as he still does, in lying on his back or sides, and in sitting with his back against a supporting object, and with his gluteal and ischial regions pressed hard against whatever seat he has selected in cave or drawing-room, we need not travel far in thought to understand how great has been the preponderance of stimuli from friction and pressure on the dorsal and extensor surfaces over those on the ventral and flexor—and here comes in our familiar "total experience" with stimulus and response spread over a vast stretch of time. It must be borne in mind that from the facts of the case a very large number of individual men and women were exposed to similar, but not the same stimuli at each stage of the process involved. It is matter of common knowledge that not only on the palm and sole of man, but on regions where the skin is not specialised in that remarkable manner that is found in those regions, but also in others, that increased pressure and friction will very soon cause a harder and thicker growth of epidermis, as on the skin over a projecting bone in club-foot, over the

shoulder where a weight is constantly carried, on the knuckles of many manual workers, and over the patellæ of a devout Roman Catholic, as I have often seen.

On the other hand what conditions more calculated to thin and soften the skin could exist than those operating on the ventral and flexor surfaces, axillæ, groins, external genitals and the bends of the elbow and knee-joints, where pressure, with little friction and greater warmth and moisture prevails? I need do no more than ask which is the more reasonable of the two forthcoming explanations of such phenomena, on the one hand that they are adapted *for*, and on the other adapted *by* this experience? I doubt if at any stage of the long process this slow manufacture of differing fabrics ever conferred on man any survival value or better matrimonial prospects. At any period or stage which I have supposed it can only be claimed for the results on the skin that they did *not* cause the animal to pass through the meshes of the sieve, and theoretically might be classed among the *indifferent* modifications, even if they added a little to the comfort of their possessor.

Skin of Palm and Sole.

One can examine in more detail the remarkable form of skin which is found to cover the palmar and plantar surfaces in many mammals. It is highly specialised and appears in many degrees of efficiency for the purposes, or uses, of walking and climbing, grasping and discrimination of objects. With two or three insignificant exceptions these are the only regions even of man's body where hairs do not grow in the normal state, and in most other mammals hair is absent from the component parts or pads, which correspond to our palms and soles. In the absence of hairs and sebaceous glands and the presence of as many as 320 sweat-glands to the square centimetre, and especially the papillary ridges, the mammalian hand and foot present a fruitful field for study. They have been studied by none more earnestly and thoroughly than Dr. H. Wilder Harris and Mrs. Wilder Harris (*née* Inez Whipple). This small area of skin as an organ for grasping and discrimination has been studied by persons from different, but not conflicting points of view. Time would fail me even to mention these, but I would recall here one aspect of the matter, that is the name given to it by these eminent authorities, Friction Skin. I think I do them no injustice, nay even honour, when I claim them as allies for us "Old Contemptibles" in the struggle, Lamarck *v.* Darwin in respect of these characters of the "mammalian chirodium." This is a term employed by them for the hand and foot of all mammals,

and is very convenient for descriptive purposes. From this point of view this organ has been produced from more generalised ancestral structures by reason of friction and pressure, and not for the purpose of resisting them, at least in their initial stages—again, adapted *by* and not adapted *for* meeting those forces. There are other views of the matter held by Pan-Selectionists, notably that of Dr. Hepburn, in regard to the papillary ridges. He would, as I gather, treat them as primarily induced, by selection, for the better grasping of objects cylindrical or more or less globular. I have referred elsewhere¹ at some length to this in a book describing the examination of the hands and feet of eighty-six species of mammals. The varieties of epidermis were divided into the smooth, corrugated, scaly, nodular, hairy, rod-like and ridge-covered forms, also four mixed varieties, such as corrugated with coarse transverse ridges on the digits, corrugated with papillary ridges, nodular with papillary ridges, and hairy with coarse transverse ridges and smooth pads. Of these the species with smooth epidermis and hair are few and unimportant, and the largest group examined was that of the Primates, thirty in all, in which papillary ridges were always present. It is highly probable that the causes of these modifications of the epidermis in diverse groups of animals could be traced to the habits and modes of life of each, but I make no attempt here to do this. It is also matter for inquiry, upon which no agreement has apparently been reached, how it came to pass that man has virtually lost his hairy coat, and in regard to the palms and soles of animals, what may be the reason that so few have any hair on them, and why man has no sebaceous glands, but has very numerous sweat-glands in these regions.

This is all of great interest, and possibly some day the Mendelians will solve for us the mysteries thereof. But here I need only ask how it would have been possible for hairs to grow, or, if growing, not to be promptly worn away on a surface used by animals from monotreme to man for walking-pads, and by most of them also for grasping and discrimination between objects as well. We are so familiar with the thickening of the skin on the hands of manual workers and on the feet of those who walk much, to say nothing of what we call a “corn,” from pressure of tight boots, that we are in danger of forgetting that the protecting skin over the hands and feet of animals was of necessity adjusted in a crude way to the measure and kind of walking in past ages and in all levels of life, and that it is maintained in that adjusted condition by the use, or disuse, of each life. Another familiar example is

¹ *The Sense of Touch in Mammals and Birds.* A. & C. Black, 1907.

that of knee-pads, as in the gnu and other ungulates. Some such process it is legitimate to assume whether it be reckoned backwards to monotremes or later levels of life-forms. We see then before our eyes how this living tissue becomes adapted in varied ways by response to the stimuli of friction and pressure, and the modifications thus slowly effected must, one would suppose, be transmitted to offspring ultimately from the original groups with which the process began, when by frequent repetition small changes of structure have arisen at last. I acknowledge the limited force of the answer, that this picture involves the continuance in each succeeding generation of the stimuli which initiated the changes, but the fact remains that *ex hypothesi* the changes are there, written in tablets of animal tissue, and that the making-up of an organism in course of many ages is not and cannot be conceived as being governed alone by the "tyranny," even in the *good* Greek sense of that word, of rigid unit-characters.

In the assumed process the correcting force of the Lamarckian drill-sergeant is always at hand, as it superintends the construction of tissues and parts, and I doubt if even Professor Thomson will here interpose the difficulty of "correlation with useful characters," for the only important functions which are invoked as the invariable antecedent of these structures are the elementary habits of walking, climbing or grasping objects in certain different ways, and without these habits or functions there would be neither lemur, monkey nor man to interest the mind of a biologist from Mars. As I am desirous of condensing such replies as I can make to certain opinions of opponents and objections, I will remind the reader that Professor Bateson in the *Jubilee Volume* of 1909, pp. 100, 101, uses a metaphor to illustrate his view that among the facts of nature we meet certain definite structures and patterns in which we ought not, if desiring rightly to interpret them, to expect to find *purposefulness*. He says: "Such things are, as often as not, I suspect rather of the nature of tool-marks, mere incidents of manufacture, benefiting their possessor not more than the wire-marks in a sheet of paper, or the ribbing on the bottom of an oriental plate renders these objects more attractive in our eyes." Metaphors are both indispensable and delightful, they are the very salt of scientific and other sober writings, but they have a rather "slim" way of betraying their employers. They express at times the truth too well, and at others when vague and inaccurate lead the reader right astray. Thinking of this metaphor of tool marks I was in a modern church the other day and saw just before me a stone pillar the pediment of which was marked with oblique parallel marks of a mason's tool.

Here then there were marks left by a human hand at some date or other and by means of some tool or other. I know one may not reason by an analogy from inorganic to organic phenomena in which the push and force of life is in full blast, and that inheritance in the former is ruled out ; but, taking the metaphor seriously, you have to account for the appearance of the ribbing of paper and the mason's marks on the stone. To call them "by-products" or "tool marks" or *obiter facta*, or by any suggestive name, does not advance the reply to the question, "Whence came this great multitude?" If I were unwary enough to be here trying to attack Selection and to respond to the invitation of the more learned arachnida to walk into his parlour with a scheme of organic evolution for him to demolish at his leisure, I should have to enter upon the question of adaptation, specific difference and perhaps other great disputed doctrines. But, knowing my own limits, and desiring to keep to the self-imposed limits of the title of this book, I again plead that I am here contending, as all through it, for the origin of initial modifications by use and habit, and for nothing else. No one who reads of the immense amount of research and learning that are being carried on by the students of Mendelism and Mutationism can fail to admire them. But, as I have remarked before, these are systems of thought which in the main deal with characters by distribution or "unpacking," as it is called. Such a process of course leads to new characters by amphimixis, and no one of whom I know denies it. Such work is concerned with fresh views of the origin of species, but with lamentable cowardice, or humility, I leave all that great sphere to those who are incomparably more fit for it, and just seek to mind my own business.

In subsequent chapters on modifications and their origin I shall not need to repeat these observations.

Some Chosen Examples of Palms and Soles.

The facts then of a few selected examples of the palms and soles of mammals are shortly these.

A heavy, burrowing animal, the *earth wolf* of the Cape, has a very smooth, hard epidermis covering its foot-pads and is thus a generalised structure which I have found in no other animal.

The common *mole* which uses its broad strong fore-feet like a pair of spades, and depends chiefly for discrimination of its habitat on the delicate sensory nerve-endings of its snout, has a hard nodular skin which is much less developed on the hind feet than the fore feet, the latter being less active tools. It has no papillary ridges, in accordance with this fact, and is a very efficient miner that never

practises ca' canny, as we know to our cost when we go out in the morning and find great heaps of soft earth thrown up in the line of its advance from its base or fortress. Such a mode of life lends itself remarkably to the kind of skin on its feet, and this is *now* at any rate adapted to its environment.

The *capybara* is a large, heavily-built rodent, and has rather a smooth epidermis not specially thick, with long and efficient papillæ of the corium shown in microscopical sections. Being largely aquatic in its habitat, and given to frequenting marshy ground and to enjoying as much sleep as it can manage, it depends a good deal for discrimination of objects on its sensitive corium, and its epidermis is not much specialised for, or by friction and pressure in walking. It does not acquire by reason of stimuli and response any unnecessary tools.

With this may be classed the *echidna* or Australian ant-eater which has sparse hairs set on a hard and slightly corrugated epidermis, and, being mainly a nocturnal animal and living a secluded life, it does not walk much or far in its stealthy pursuit of worms and insects, and the stimuli of friction or pressure encountered by it are few.

A similar condition is found on the feet of many small carnivores.

Animals with scales on their feet, which are held to constitute the earliest stage of the Primate modification of papillary ridges are such as the *potoroo*, *wallaby*, *kangaroo* and *giant ant-eater*. Such scales register a long, long series of stimuli of friction and pressure in these and their ancestors, in a level of life before any delicate discrimination of surfaces came into operation.

The nodular form of skin is present in the Canadian *tree porcupine*, where rough nodules cluster closely on the surface of both feet, and it is a significant fact that it shares with the American *opossum* the peculiarity of nodules on the ventral surface of the powerful prehensile tail. This adaptation tends to efficiency in its arboreal life, and may well have been produced by infinitely small degrees of response in structure in the course of a long evolution.

The *rabbit* alone have I found with rod-like projections of the epidermic cells, among which are set in dense order the soft, long, delicate hairs and which thus conduce to its wonderful power of treading on sharp objects without injury. We thus see the inner meaning of dear old Brer Rabbit's jeer of triumph to Brer Fox, "Born and bred in a brier bush." This adaptation might be an unit-character segregated from the ancestral stock of the Leporidæ, or it might not, but at any rate the rabbit leads a life in which its

walking or running is no more prominent or frequent than is a good "run" on the part of a hunter which pursues the hare with his beagles, and one may say at least this—that its mode of life has *not* produced a hard rough nodular surface on its feet by stimuli of pressure and friction and response.

One may observe that there's a divinity doth shape our ends, rough hew them as we may, even if some objection be taken to the present view of rough-hewing of parts of our organism on the ground of its piecemeal character, rather than dealing with the organism as a whole. To which it may be replied that the Mendelians give high support to the piecemeal study of the profound subject of genetics, and further that the business here is to look separately and simply at a few selected attributes of parts of an organism, and see how they *began* to grow big enough to avoid passing through the meshes of the sieve.

The foregoing examples of animals in which papillary ridges are absent have been given not in their zoological order, nor as representative of a great many groups, but as taken from the eighty-six species I examined myself. The following belong to the same series, but all present papillary ridges in an ascending scale towards perfection in man.

Examples of Ridge-covered Palms and Soles.

The common *hedgehog* though a burrowing animal like the *mole* is not always underground as his distant relative is. He is not always mining and though of ancient lineage he is a "slacker" compared with the mole, hibernating for months, and spending also much time in his nest and prowling slowly about above ground for insects. He has thus acquired his somewhat indifferent epidermis that one finds, but with the addition of sparse papillary ridges. It is the species among this list with the fewest of these tactile structures, for there are but three or four separate ridges on six of the ten digits, and radiating groups on only three of all the palmar and plantar pads. So *quâ* touch it is ill-equipped, though it has adapted a higher form of tool than the rabbit.

The common *squirrel*, that sits much and walks mainly on branches of trees just as much as it needs to do, has an epidermis little differentiated, and one which is corrugated with scanty papillary ridges on the palmar and plantar pads, and none on the digits.

The *squirrel-like phalanger* which flies always more or less downwards by a kind of parachute-arrangement has most of its palmar and plantar skin covered with papillary ridges encroaching

upon its corrugated areas, and a response to more delicate tactile experience has been thus produced by its intermittent performance of ordinary progression.

Azara's opossum presents about as large a part of the surface covered with nodules as with papillary ridges, the latter highly-developed for an animal so low, zoologically-speaking, but one in which delicate discrimination is much practised.

The *kinkajou*, another arboreal animal which walks about on trees more than it uses its feet for prehension, trusting much to its prehensile tail, shows its corrugated epidermis and papillary ridges developed in about equal proportions.

These five mammals thus show that the stimuli of pressure and friction and the response to them are being complicated by the addition of the more delicate tactile organs known as papillary ridges, and these, perhaps, in a secondary way are becoming useful in preventing friction. But I must not omit to point out that, *quâ* prevention of slipping, the few sparse papillary ridges of the *hedgehog*, *squirrel*, *kinkajou* and *flying-phalanger*, especially those on the extreme tips of the digits, could have no effect in this prevention and no survival value. It is otherwise when they are developed in large areas as in the succeeding groups.

Primates.

All the thirty species of Primates possessed papillary ridges to such an extent that only small areas of the palmar and plantar skin of the lemurs showed any other than these remarkable characters. It is so much a property of the Primate hand and foot to possess these that it might be almost made a matter of ordinal rank belonging to the Primates, were it not that a few stray lower mammals also possess it.

The *black-headed lemur* is the lowest Primate examined and it is characterised by highly developed patterns of ridges on the palm and sole, and these are interspersed with nodules on the regions less exposed to pressure. The complexity of the patterns of another, the *ring-tailed lemur*, is greater still. Now these nodules are distinguished from the rough undifferentiated nodules of lower forms, such as the Canadian *tree-porcupine*, and from the scales in others. When examined with a lens the separate nodules show small groups of papillary ridges two, three or four on each nodule, arranged in a direction parallel to those of neighbouring nodules. They are in fact papillary ridges in embryo, and shortly above this lemur-stage in the ascent of animal life they are merged into papillary ridges in patterns. All this is well told at length by Dr. and Mrs.

H. Wilder Harris. I refer to it here because the disappearance of the rough, plain, nodular or corrugated epidermis in mammals is coincident with increasing activity and intelligence in forms who employ or acquire a more delicate sense of touch in their hands and feet. The cruder response of structure to stimuli of friction and pressure, evident in the lower forms, is abandoned in the higher, as tactile delicacy in prehension comes more into play. Here, for example, may be a subtle case of the co-operation of the mould and sieve in action.

From this lemur-level the degree of development in the Primate palm and sole rises and falls, but always advances through the *lemuroidea*, *monkeys* and *anthropoid apes* to man. No attempt at the tracing of the lineage is made here, and from the present limited point of view little remains to be said about different Primates. Only two of those examined will be briefly referred to, the *slow loris* and man.

The *slow loris* shares with many monkeys and apes a very soft moist skin of the palm and sole, and in this and other refinements of this region it is much beyond many more intelligent, active and higher Primates. I have never had social intercourse with a *loris*, but I have shaken the friendly little hand of a *chimpanzee* with a combination of pleasure, mild shock and perhaps memories of my own palms in the more nervous moments of early life. It is a strange, cool, soft and damp surface, but the sensation conveyed by the skin of a *loris* lately dead show that in life it is a wonderfully sensitive and tender structure. The whole of the palm and sole is covered with well-developed patterns of papillary ridges especially on the palmar and plantar pads. No trace of old-fashioned nodules, scales or corrugation is to be found. The structures due to stimuli of friction and pressure in its ancestors have disappeared for ever from this specialised and small group, and we may fairly hold, in accordance with the law of conservation of energy, that the past is somehow enwrapped in the present in the strange hands and feet of the *loris*. The adaptations of the hand and foot of the *loris* are most obviously now of value to it in its wary and dangerous life in the branches of trees, but are equally unfitted for that higher life which, in his case, consists in going lower down, on the ground. The extraordinary deliberate life of the *loris* has been often described. As he moves from place to place on a branch, fixing one limb before he moves another, much as we do in going up a ladder, he is subjected much to the stimuli of pressure, but hardly at all to those of friction. He sets us a good example of leaving nothing to chance. Thus his soft sensitive skin suits well his mode of progression, but he

would find the harder, rougher skin of an African baboon very inferior for the purpose. Here, indeed, I have ventured on the edge of Tom Tiddler's ground, and the Pan-Selectionist or Mendelian will make a grab at me so that I escape with just the loss of a portion of clothing. After escaping I have only to observe to him as to the adaptations of a *loris's* hand and foot that in human life, of which we know a little, one can in a measure forecast what a man will be like if we are told on reliable authority what he and his ancestors have *not* done in the way of muscular or cerebral output, without information as to what he has done. This is too obvious, but also too complex to prove here by numerous illustrations and it may be left as a mere suggestion as to the past life of the *loris* and his ancestors for many generations. He has *not* walked in the ordinary method of terrestrial mammals, he has always moved very slowly about the branches of trees, he sleeps most of the day in a hollow of a tree, curled up like a ball, and his home is in moist, tropical regions. No habits and conditions of life could be better calculated to soften and moisten the skin over his palms and soles or expose it less to stimuli of friction, while even those of pressure in his tenacious grasp of boughs are decidedly intermittent. Unless one may assume the appearance in the distant past of some unit-character of soft, moist skin in this and other Primates, it seems difficult to refuse the Lamarekian claim of long, long absence of effectual stimuli of friction and equally long presence of enervating "negative" conditions. Proof of such a view is, of course, wanting.

Palm and Sole of Man.

The palm of man's hand is a miracle of adaptations for touch and grasping, but has lost most of the coarse structure formed in response to stimuli of pressure and friction which we saw were common in lower mammals. This indeed he shares with most simian forms. The skin of our hands is now very much what we make it and responds very soon to fresh positive or passive conditions. The horny, cracked epidermis on palm and digit of the old sailor may be contrasted with the soft and flexible and pale surface of his twin-brother, the bank clerk, who is of studious habits and has neither the vice of gardening nor golf. If one compares the hand of the ordinary maid with that of her mistress the difference is striking. But if one compares the hand of that mistress with that of her spinster sister who has lain for twenty years in bed or on a couch, the difference is equally significant. Indeed the sofa-and-bed-ridden invalid, of whom I knew a few once, but who have gone out of fashion, gives the observer some useful thoughts as to the

why and wherefore of the strange skin of the hands of the *slow loris* previously referred to. And if he be disposed also to the pleasant pursuit of moralizing at the expense of others he will feel led to reflect over harshly on the invalid and compare her outlook on life with that of the *loris*. Even in this concrete case of the hand of an invalid there may be evidence of positive as well as negative response, if one examines the right forefinger so much used in sewing, where the skin becomes hard and thick.

The foot of man has a good deal of negative evidence in favour of my contention as well as positive. As to the latter, in the thickening of the skin over the heel and ball of the great toe in those who walk much we find changes precisely similar to those on the hand. The negative or degenerative changes visible on man's foot consist chiefly in the remarkable simplicity of pattern of the papillary ridges as well as their flattening and blurring, through wasting of those which occupy mainly the arch of the foot. These will be shown in the next chapter in a drawing. When this portion of skin is compared with that of the foot of any monkey or anthropoid ape it is clear that in this respect the skin of man's foot has undergone even more degeneration than his hand has shown of higher development. This degeneration has coincided with two facts, first that man's terrestrial locomotion has advanced far beyond that of any other Primate, and second, that he alone has a plantar arch. This subject belongs to a later chapter and is referred to here because the possession of an arch to his foot has caused man to escape, on the under surface of it, a vast proportion of the stimuli of pressure and friction involved in his mode of walking, and the extreme simplicity of his plantar papillary ridges, and relatively thin, soft skin under the plantar arches affords a fairly conclusive example of change of structure from disuse *per se*.

I have thus only selected and used two striking types of the Primates, the *loris* and man, not wishing to burden this part of the subject unduly with intervening and less characteristic forms of life. It may be legitimate here to say in defence of this long chapter that it illustrates what I desire to keep before me all through, the fact that use, habit, environment and selection go ever hand in hand. In all matters of science one has to descend to particulars, so it seemed necessary to select a few scattered phenomena in the best known groups of higher animals and endeavour to understand how certain "characters" or better "modifications" began to grow big enough to avoid passing through the meshes of the sieve.

CHAPTER XVIII.

ARRANGEMENT OF THE PAPILLARY RIDGES.

THE subjects of the preceding, present, and the succeeding chapter are closely allied, from the fact that they all deal with structural changes in the mammalian skin, and that most of these are exhibited for us on our own palms and soles. They certainly comply with the canons of Henri Poincaré as to simplicity, regularity and chance of recurring.

In the last chapter, papillary ridges as organs of touch were briefly referred to, but their mode of development into complicated patterns do not concern the questions here at issue. The general manner in which they are arranged on the hands and feet of man and the Primates below him is very much a matter for such Lamarckian methods of inquiry as I have chosen. In this examination of the ridges I will proceed from man backwards among the Primates and lower still. I described these ridges, in a book previously referred to in the following words, and find no need to alter them here. "The ridges and adjoining furrows which cover the palmar and plantar surfaces of all Primates and a few lower forms in smaller degree, may be compared to the ridges of a ploughed field over which some object, as a light roller, has been passed, the effect of this being to produce a series of ridges with flattened tops. This can be well seen with a lens when the ridges are examined in profile, and is their normal condition in man and many lower animals, in nearly all the palmar, plantar and digital regions."¹ The reservation in the last sentence is not material here.

The Hand of Man.

Beginning with the tips of man's fingers and excluding the wonderful patterns which Galton did so much to elucidate and bring into order, we find the ridges are placed, to a remarkable extent, parallel with the skin-flexures which will be treated in the next chapter. I term the thumb and fingers D 1, 2, 3, 4, 5 for the sake of accuracy (Fig. 59). Over the last joints (distal) of all the digits the ridges suddenly diverge from their directions in the patterns of the pulps, and become arranged transversely to the

¹ *Sense of Touch in Mammals and Birds.*

axis of the digits. This arrangement is observed on the remaining segments of the digits except, very significantly, on the outer or radial side of D 2 and the inner or ulnar side of D 5 where they slope more or less towards the palm. Their lines thus cross slightly those of the skin-flexures in these small areas. On the radial side of D 1 this slope appears in a minor degree, but here it coincides

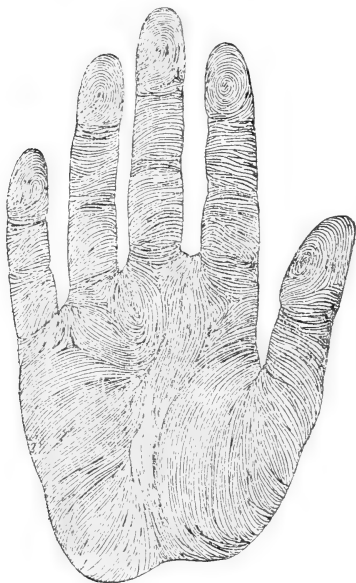


Fig. 59.—W. K. Right hand drawing of papillary ridges, made from impressions.

with those of the flexures. On the palm are similar arrangements of the ridges near the radial and ulnar borders, and especially on the two great eminences, thenar and hypothenar, also at the bases of digits 2, 3, 4 and 5. Over the rest of the palm they are arranged in a longitudinal or oblique direction. These brief descriptions are enough to show the close correspondence of the arrangement of the ridges with the flexion of the numerous joints of the hand. An observer can demonstrate this by holding up the open hand in

a good light and flexing the fingers slightly, which brings nearly all the ridges adjacent to the joints into directions parallel with one another, the greater lengths of D 3 and 4, and their closer functional connection with one another, producing thus a transverse arrangement, and in D 1, 2 and 5 a more oblique one. In the palm this correspondence of ridges with flexion lines of joints is not found so much except in the central part of this surface. But the oblique and longitudinal ridges of the palm where it becomes concave in the action of folding the hand over a globular object are well shown there also to correspond with such action.

This general grouping of ridges is seen, *mutatis mutandis*, to belong to all the palms and soles of lower Primates, and the illustrations given will speak for themselves, so that little need be said on each.

Reasons for Arrangement Observed.

When one discusses the forces in action on man's hand which are claimed to have thus arranged the ridges, in regard to the question of use and habit, little more need be added as to those of other Primates, and it is because we know more about ourselves than them, and our own palms and soles are available for inspection, that I have taken man as the example.

The main question is the old and now familiar one: "Are these ridges arranged as we see them *by* use and habit, or adapted *for* use?" Dr. Hepburn and the orthodox Selectionist would say that, of course, their mode of arrangement is an adaptation governed by selection for preventing slipping in the action of grasping an object by the hand, and in the foot for preventing slipping in walking. This does not take into account the question as to how the original slight shifting of the ridges in the earliest man and in lower forms could have had selective or survival value, for example, the insignificant sparse groups of ridges on the palm, sole and *tips* of the digits in a hedgehog or squirrel. As things are now they *do* subserve these purposes. But I think this matter of prevention of slipping has been much exaggerated, though I may be told that this is a matter of opinion and not a valid argument against the hypothesis.

Foot of Man.

The point may be best understood by considering the foot of man, of which Fig. 60 shows a good example. The value of the roughened surface of the foot with its papillary ridges can hardly have been great, even in the days when man's foot was naked, at any rate so little that for him to acquire by a selectional process

such a remarkable *change* of arrangement as we see when we look at the foot of man and of any other Primate involves on our part a tremendous stretch of imagination as to its *modus operandi*. These low, soft ridges of man's foot could do little to prevent him

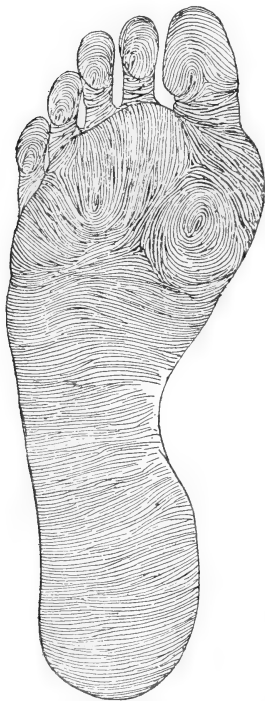


Fig. 60 S. K. Right foot drawing of papillary ridges made from impression.

from slipping on such surfaces as grass, sand, rock, wet or dry, and from the time when he began to protect his feet with coverings this small value would be further reduced. *Underneath his developing plantar arch it would not exist at all, and yet here especially he has changed their direction.* As to the papillary ridges, man's foot has sadly embarked on the pathway of degeneration much as his little toe has done. Not only has he here a much simpler arrangement than any ape or monkey, but the individual ridges are blurred and flattened on much of the plantar surface. This comes of his pride in acquiring his human distinction, or title of nobility, of a plantar arch and his coincident increase of pedestrian locomotion. On the triple bases of support, heel, ball of great and little toe, the ridges are still strongly marked and coarse; transverse on the heel, whorl-like on the ball of the great toe, and oblique or nearly transverse on that of the little toe. On the rest of the surface they are vulgarly transverse. And I may add that the toe-prints of man are simplicity itself compared with his finger-prints.

It would seem that this example of arrangement of ridges on man's foot is strongly in favour of the hypothesis that they are so disposed by flexion of the foot in walking, and not by some need for prevention of slipping under the guidance of selection.

circular pattern of ridges, is obviously quite unadapted for any non-slipping effect of its skin, as a glance at the figure shows. On the remaining segments of the digits the ridges in the main slope from each side of each digit in the distal direction and fail here also to obtain the best, or transverse direction for preventing slipping in locomotion. The corresponding surface of D 1 is not different from its pulp as to direction of ridges, and it is here to be noted and admitted that when this muscular great toe is tightly applied to a branch, which from its shape it must cross at a right angle, the non-slipping effect of the longitudinal ridges would be very effective. One must then notice that over the middle of the sole of this foot the ridges have again changed their direction and lie in a transverse direction. Between this and the basis of the digits are three fleshy pads and an intervening area of longitudinal ridges.

The first question that arises in the attempt to analyse so complex a grouping on a strange member like the foot of a *loris* is this—what is the primary function subserved by the ridges and their mode of arrangement, and what may be their secondary uses? In the book referred to I have maintained throughout, in opposition to Mrs. Wilder Harris and others such as Dr. Hepburn, that the sense of touch is the primary, and prevention of slipping the secondary adaptation secured by the ridges. If this be true (and I know it is *sub judice*) there is a very clear reason why the ridges should be longitudinal on the tips of the digits on account of the better discrimination of small objects secured by this arrangement, though it does not well assist the *loris* to avoid slipping. On D 1, as mentioned, the non-slipping effect *is* secured by its ridges, and this digit is necessarily less employed for discrimination than support. On the other hand the sloping arrangement on the rest of the segments of D 3, 4, 5 is decidedly less effective in preventing slipping than a transverse arrangement would have been. I think I am justified in saying that too much has been made of this secondary effect of the ridges in the prevention of slipping. I know that the string wound round the handle of a cricket bat is very effective for its purpose, but one can also understand that a casual strand wound here and there on the handle as the ridges are on a *hedgehog's* and *squirrel's* hand and foot would be of little use for the purpose.

On the other hand if the view may be entertained that on the palm and sole of *hedgehog*, *squirrel*, *loris* and man, we have written in rows of papillary ridges and their modes of arrangement a register of long-continued flexion of hand and foot in flexion and correlated

actions, we find the facts of these and numerous other Primates agree in a remarkable manner with the hypothesis; whereas the exclusive non-slipping rival has many awkward facts to explain, or disregard.

Further as one has always to bear in mind the Mendelian analysis it should be observed that the extreme variability, within certain limits, of the arrangements of papillary ridges throughout the Primates renders the hypothesis of unit-characters segregated, according to Mendelian laws, wholly inapplicable to the *manner*

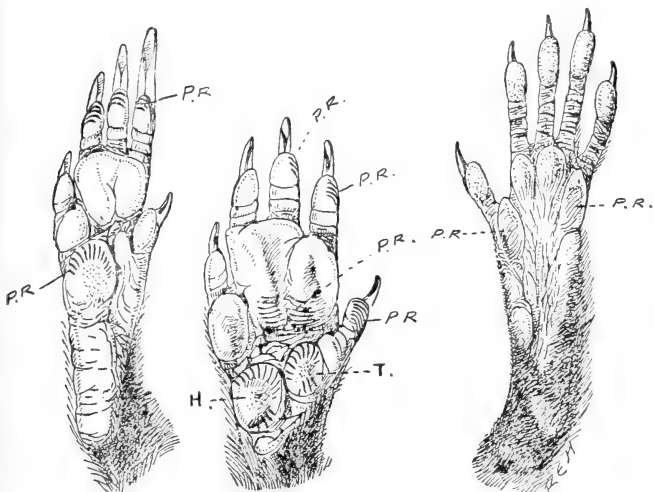


Fig. 62.

Fig. 62A.

Fig. 63.

Hedgehog—right foot. Hedgehog—right hand. Common squirrel—left foot.

of their arrangement even though perhaps not so to the *existence* of papillary ridges.

It may be bluntly asserted that the ridges are arranged as we find them because, hands and feet being used as they are, the ridges "can do no other," and that there's an end of it, and that we cannot derive any help as to the origin of specific difference from such a trifle, the next item on the agenda should be called for. As a piece of dialectics that would be effective, but if taken literally it only goes to prove my simple contention.

It will be enough to mention the hand alone of the remaining series with a note as to each animal.

Fig. 64 gives the hand of a *chimpanzee* with ridges on the pulps resembling those of all the *apes*, *monkeys* and *lemurs*, arched groups on the digits and longitudinal ones on the centre of the palm, both of these last two being exactly what would be found arising from

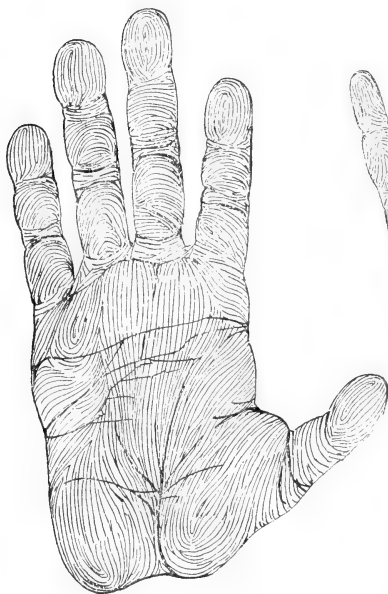


Fig. 64.—Chimpanzee—right hand.



Fig. 66.—Orang—right hand.

the actions of climbing branches and discriminating globular objects in the palm.

Fig. 65 is that of a *gorilla* and its general features resemble closely those of the *chimpanzee* and of Fig. 66 which is that of an *orang*.

Fig. 67 of a *Hainan gibbon* is very different on the palm from the other three apes for its ridges are nearly all longitudinal or

slightly oblique, precisely as one would find this part if the *palm* were used very little for grasping boughs and much for discriminating globular objects procured for its repasts. The wonderful long digits of the gibbon form its main organ for supporting itself on branches and swinging its body rapidly from branch to branch, and the arched or nearly transverse ridges on the digits are placed just as the endless use of them for this purpose would

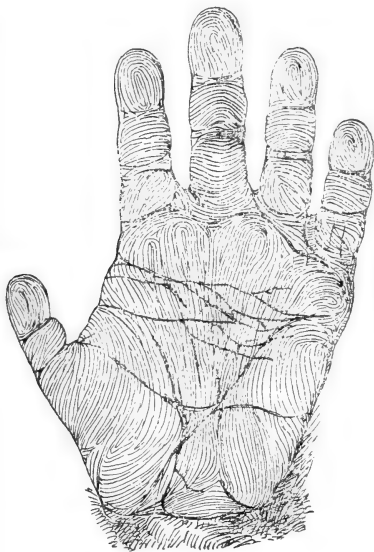


Fig. 65.—Gorilla—left hand.

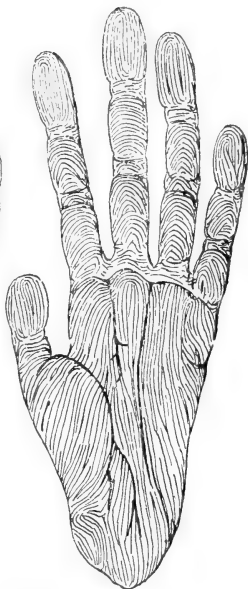


Fig. 67.—Gibbon—left hand.

be likely to follow from it. This example is a very clear one for showing, if it exist, the effect of use and habit on the disposition of the ridges.

Fig. 68 shows the arrangement of papillary ridges in a *lemur* and 69 that of a brown *sapajou*.

Fig. 70 of the *Chacma baboon*, playfully called by the Boers Adonis, is a very active and wary animal which lives on the rough rocky slopes of the Cape. It is very much of a pedestrian and the

response of its mode of life and use of its forefoot is shown in five great pads of muscle and efficient whorls of ridges for touch, those on the digits being very nearly all transverse in accordance with simple flexion of these joints. This again is what one would expect if my hypothesis be sound. The purely non-slipping mechanism supposed by the rival view is not here well supported by the facts.

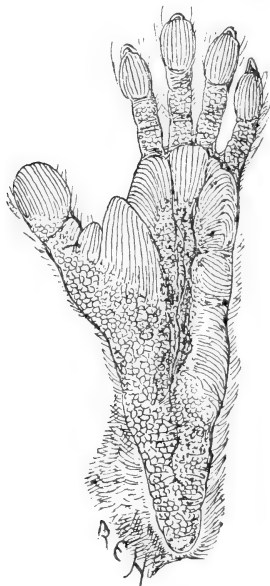


Fig. 68.—Left foot of ring-tailed lemur.



Fig. 69.—Brown sapajou, right hand.

Neither the arrangements of ridges (Fig. 61,) in *loris*, nor the *hedgehog* (Fig. 62), nor the *squirrel* (Fig. 63), need further reference, but they are all, I think, very consistent with the prolonged effects of use and habit.

Some Undesigned Experiments in Ridges.

This section of the subject has afforded a good supply of indirect evidence, but so far no direct proof that papillary ridges

can be created and disposed in their lines by pressure, friction and response. The clearest case is one I brought forward at the Zoological Society of London in 1905, and which was published in its proceedings of April 18th. It was an instance of the hand of a *chimpanzee* with papillary ridges produced in an aberrant or abnormal situation by walking, and was given as follows :—

“ In the course of an examination of the papillary ridges in some specimens of anthropoid apes and monkeys certain groups of ridges were found on the *extensor* surface of the terminal phalanges of the hand, apparently identical with those of the palmar and plantar surfaces. Three specimens of chimpanzee living in the Society’s menagerie were examined, of the ages : one year eight months, two-and-a-half years and six years. In the oldest of these, called “Mickie,” the ridges were definite and well-developed, on the second, third and fourth digits on both hands ; in the youngest specimen, “Jack,” they were absent ; and in “Jimmie,” two-and-a-half years old, they were small and ill-defined, as if in process of development.

Direction of Ridges.

Mickie. Ridges longitudinal and reaching to the matrix of the nail on the second, third and fourth digits.

Jimmie. Showed ridges as follows :—

| | | | |
|---------|--------------------------------|---------|----------------|
| R. hand | 1st D none | L. hand | 1st D none. |
| | 2nd „ oblique | | 2nd „ oblique. |
| | 3rd „ transverse at base of D. | | 3rd „ „ |
| | 4th „ „ „ „ | | 4th „ „ |
| | 5th „ nearly longitudinal. | | 5th „ none. |

In these three specimens ridges were absent from the corresponding surfaces of the foot.

“The well-defined longitudinal direction of the ridges in “Mickie” is worth notice. It must be remembered in this connection that a chimpanzee walks with the extensor surfaces of the phalanges touching the ground and the digits turned inwards, so that their long axis are at right angles to the line of progression of the animal, and accordingly the ridges of this part also occupy the same relative position. There is no correlation in this instance between the act of prehension and the direction of the ridges, though it agrees closely with the general rule which obtains in so many regions, that the ridges lie at right angles to the line of incidence of the predominating pressure on the part.”

In this example of ridges developed on an abnormal situation we see what is, perhaps, an undesigned experiment as to the production of ridges by a more frequent habit of walking in captivity than would be found to occur in the wild state, for, as Lydekker says in the *Royal Natural History*, Vol. I, p. 27, "When the chimpanzee goes on all-fours, he generally supports himself on the backs of his closed fingers rather than on the palm of the hand (see Fig. 6 of the illustration on p. 15) and he goes *sometimes* on the soles of his feet and *sometimes* on his closed toes."



Fig. 70.—Left hand of chacma baboon.

I have underlined purposely this word "*sometimes*," for in the instance I have described, not only the presence of the ridges and their direction on the backs of the fingers but their absence on the backs of the toes is significant, and I suggest that the *chimpanzees* examined have not sufficiently often exposed the backs of their toes to pressure and friction for the production of ridges, whereas those on the backs of the fingers have done so. Another point worth notice is that in the oldest of the three *chimpanzees*, "*Mickie*," æt six years, the greatest number of ridges is present; in "*Jimmie*," æt two-and-a-half years, they were

"small and ill-defined as if in process of development," and in "*Jack*," æt twenty months they were absent. This would agree at any rate with the hypothesis that the element of time and frequent repetition of stimuli enter into the causation of aberrant ridges.

A similar condition, with aberrant papillary ridges, has been found on the digits of the hand of the *orang*.

On the heel of adult man ridges are found surrounding it, of the average depth of one inch from the plantar surface, and in one

particular case of a woman aged forty-nine, the depth of this area on each foot measured was one and a half inches from the plantar surface.

The extensor surface, or back, of the little toe shows ridges when it is distorted by ill-fitting boots.

In man ridges frequently appear on the radial side of the back or extensor surface of the index finger to nearly the middle line of the finger, and this is often more on the right than the left hand.

CHAPTER XIX.

FLEXURES OF THE PALM AND SOLE.

THOSE flexures of the palmar and plantar skin which are called by Galton chiromantic creases, and said by him to be no more significant to others than palmists than the creases of old clothes, have received a remarkable amount of pseudo-scientific attention since earliest times in Chinese and Greek history. The former even added podoscopy to their chiromancy. The line of life, the line of the head, the line of the heart, the line of fortune and that of the liver, figure freely in fortune-telling of modern drawing-rooms by women who ought to be in Holloway gaol, but are not. The gipsies, their predecessors and equally honest teachers, did not employ such high-sounding words, but I believe that by observing closely the bearing, looks, dress and manner of their dupes, while pretending to study their palms, both classes of practitioners, like phrenologists, are able to tell a good deal of what their customers *are*, and being shrewd persons they are able to guess pretty well what they *will be and will do*.

I agree with Galton that these creases of hand and foot are no more significant than those of an old coat-sleeve, a pair of trousers, or boots; but they are not less significant of certain muscular habits of the wearers of those articles.¹

The flexures in question are in line with the subjects of the two preceding chapters, and require little more description in detail than is afforded by the accompanying illustration of mammalian hands and feet.

Description of Flexures.

There are two classes which may be conveniently called here Primary and Secondary, the latter being too variable and accidental for further notice. The former lie in three main directions and are longitudinal, oblique or transverse. They represent in graphic characters the nature and degree of the functions exercised by

¹ Galton might have referred by way of illustration to an immortal woman in *Martin Chuzzlewit*, who shall be nameless here.

muscles moving the joints which underlie them, and are often called "flexion-lines." They are "folds so disposed that the thick skin shall be capable of bending in grasping while it at the same time requires to be tightly bound down to the skeleton of the hands and feet, so as to prevent slipping of the skin which would necessarily lead to insecurity of prehension, just as the quilting and buttoning down of the covers of furniture by upholsterers keeps them from slipping. For this purpose the skin is tied by fibres of white fibrillar tissue to the deep layer of the dermis along the lateral and lower edges of the palmar fascia and to the sheaths of the flexor tendons. The folds, therefore, which are disposed for the purpose of making the grasp secure, vary with the relative lengths of the metacarpal bones, with the mutual relations of the sheaths of the tendons and the edge of the palmar and plantar fascia. The sulci are emphasised because the subcutaneous fat, which is copious in order to pad the skin for the purpose of holding, being restricted to the interval between the lines along which the skin is tied down, makes these intervals project, and these are the monteculi."¹

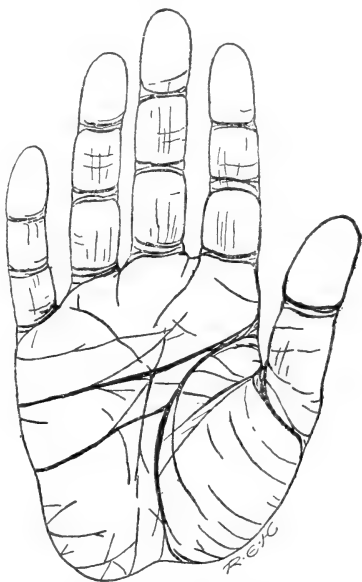


Fig. 71.—Flexures on palm of right hand.
Drawing made from impression.

This account of them from a leading anatomist shows that not for nothing have these creases been evolved. They are inherited, have an important function and are worthy of study in

1. A. Macalister, *Palmistry Encycl. Brit.*, 11th Edition.

their humble way: they may be even dignified with the name "character."

They are often double over the joints of the fingers and toes, but, from the functional point of view and for simplicity, may be reckoned as single.

Chief Types.

The most common types of them in the hand of man are shown in the example given in Fig. 71.

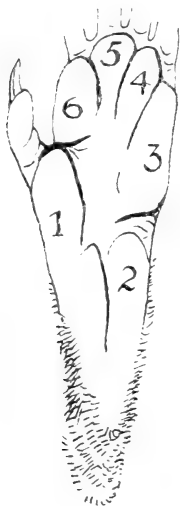


Fig. 72.—Foot of common squirrel.



Fig. 73.—Flexures on foot of vulpine phalanger.

1. A flexure over each phalangeal joint.
2. A flexure at the bases of the digits.
3. A flexure over the metacarpo-phalangeal joints of D 2, 3, 4 and 5 with an oblique direction, called *linea mensalis*.
4. A flexure over these same joints and oblique in direction, but nearer to the wrist—the *linea cephalica*. These flexures, 3 and 4, though arising from the flexion of one set of joints should be looked at as separate folds because of their time-honoured popular names.

5. A curving flexure surrounding the thenar eminence, extending from the centre of the wrist along the palm and terminating at the radial border.
6. Variable longitudinal and oblique flexures not specified, which I have called secondary.

Meaning.

Whatever be the meaning and origin of these flexures they are not mere folds such as one makes in a garment and leaves it so.



Fig. 74.—Foot of loris.

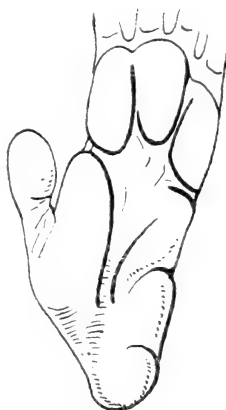


Fig. 75.—Foot of ring-tailed lemur.

Action, function and fitting of the structures of the hand and foot are involved in their history. They may loosely be termed “ergographs” without any reference to the exact measurement of work done. No proper idea can be formed of them if the original function and evolution of the walking-pads of earlier mammals be omitted. If one goes back and back until one reaches some lowly marsupial as a *vulpine phalanger*, or insectivore such as a common *hedgehog*, one may even metaphorically see these animals

being fitted by a shoemaker with rude shoes or walking-pads for the better locomotion on or under ground, or in the branches of trees. These pads are projecting masses of hard fat with fibrous tissue interspersed and they early become fitted or adapted *to* or *by* the use to which they are put. It is impossible to suppose that certain rudimentary pads are devised by selective processes prior to the altered habits of walking of the animal that acquires them. From the shoemaking point of view the fashion is rough and generalised, and the changing habits of the animal adapt the shoe by degrees to the function employed, much as many a private



Fig. 76.—Foot of squirrel-monkey.



Fig. 77.—Foot of macaque.

soldier knows to his cost that he has had to adapt slowly and painfully his army boot to his particular foot. This process in an early pedestrian mammal involves the breaking up and limiting of the rudimentary pads by sulci in the dense skin, and the process of struggle and adjustment between the pads and their bordering furrows issues in the characteristic flexure of each mammal. From experiences in the human body one knows how easily fibrous adhesions between the skin and deeper parts, notably in cases of Dupuytren's contraction of the palmar fascia, are formed by close apposition of the two layers. Such adhesion is precluded when much movement of the part occurs, but *ex-hypothesi* the rudimentary

flexures are distinguished by absence of movement, and the conditions for fixing down the deeper layers of the skin to the bones beneath are clearly present. That these are not indifferent structures is evident from what Macalister says, and though they be small or even trivial may be held to have acquired at some time or other selective value. Their early stages would necessarily be too tentative, varied and slight to acquire such value.



Fig. 78.—Foot of gibbon.

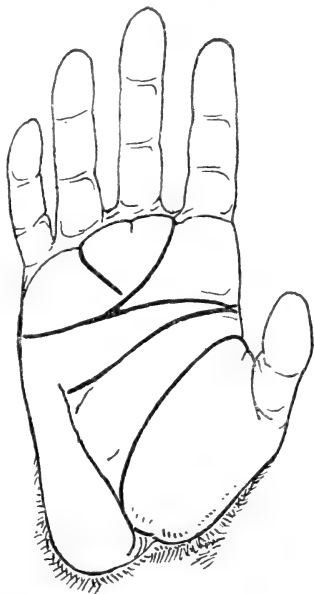


Fig. 79.—Hand of chimpanzee.

Fig. 72 is a sketch of the hand and foot of a squirrel (*Sciurus*) and the numbers 1, 2, 3, 4, 5 and 6 are placed conspicuously on the walking pads in accordance with the teaching of Dr. and Mrs. Wilder Harris as to the six palmar and plantar walking-pads, of which the typical palm and sole is constructed. The thick, black lines indicate the flexures formed round the pads by the exercise of the functions of the hand and foot.

Fig. 73 represents the clumsy, thick walking-pads of a marsupial the vulpine phalanger, *trichosurus vulpecula*.

Fig. 74, the highly-developed prehensile foot of the lorís.

Fig. 75, the foot of a ring-tailed lemur.

Fig. 76, the foot of a squirrel-monkey (*Chrysotrrix Sciurea*).

Fig. 77, the foot of a macacus (*Macacus cynomologus*).

Fig. 78, the foot of a gibbon.

Fig. 79, the hand of a chimpanzee and here the resemblance to the *hand* of man and *not to the foot of man* is very striking.

A description has already been given of man's flexures of the palm.

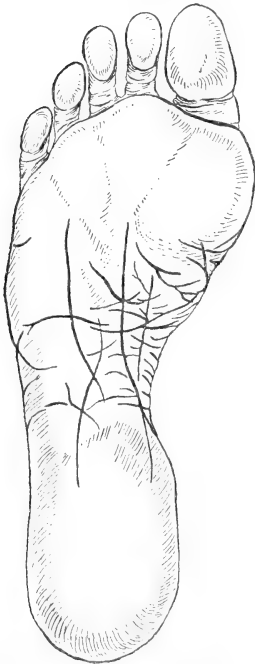
Fig. 80 is a careful drawing of the sole of a young active woman with a well-formed foot, and there is little typical in the mode of arrangement of its creases except the slight tendency to transverse lines of flexure. In all the feet I have examined I have found no single flexure that is constant, and the longitudinal ones here shown are often absent.

Reviewing these examples one observes an evolutionary decay of a minor but necessary piece of mechanism of the Primate hand and foot. The general similarity, *mutatis mutandis*, of the flexures of the palm and sole in Primates is very noticeable, and is associated with the strong prehensile power of the foot of all the forms below man.

In the cases of the two apes

Fig. 80.—Drawing of flexures of sole of foot in young adult.

shown in this series, the resemblance is still well marked, more so even in the chimpanzee than the gibbon, so that the disappearance from the sole of man's foot of any important flexure is very significant of his loss of prehensile and gain of locomotive perfection, and I find it impossible to conceive any process of evolutionary change where a loss of the



flexures of a prehensile foot could come under the power of selection, on its own merits. On the other hand this remarkable instance of disuse of a formerly useful structure is adequately accounted for by the evolution of an organ like the human foot which in course of long periods of time became an organ of one function. Weismann might score a point over Spencer from his laboured explanations of man's dwindling little toe, but here, I submit, he would have had to take refuge in silence, and pass to characters of a higher and more debateable kind.

CHAPTER XX.

THE EVOLUTION OF A BURSA.

A BURSA exercises a function in the animal body which is the direct opposite of that shown to belong to the flexures of the hand and foot. Whereas the latter are adapted to the prevention of slipping in the act of prehension, bursæ are delicate contrivances for producing the maximum effect of sliding, within certain limits, between two opposed surfaces, either between the skin and a hard surface beneath it, between two muscles, or a tendon as it moves over a bone. As they are very variable and most of them are inherited and congenital, while some are produced only in the lifetime of the individual, they are useful for consideration in regard to the questions of transmission of modifications and of the origin of initial variations. Their degree of utility ranges, for example, in man, from that of the prepatellar bursa without which no useful movement of the knee-joint is imaginable, to the insignificant bursa which may or may not be found on the dorsal surface of a phalangeal joint of the foot. The principle laid down by Lyell, to which allusion has been made elsewhere, that is, of "explaining changes in the surface of the earth by reference to causes now in action," is applicable in this small department of the evolution of a minor structure of the animal body. As man furnishes the largest of all collections of these lubricating organs, his skeleton and skeletal muscles will form the main subject of this chapter, and I venture, if one may say so, to "Lyell" them. None of the sections of this book except that on the mammalian hair affords so simple and easy a field for watching in operation certain mechanical forces. We may here go down to the potter's house and watch him moulding his clay, or the cobbler his leather. So much are bursæ in the human body under the power of extraneous forces that I venture to say that if some young surgeon of an inquiring mind were to choose a place and time when the Honourable and Vigilant Stephen Coleridge was out of the way, and were to produce in a young *chimpanzee* under an anæsthetic a "greenstick fracture" of his radius and ulna, immobilising it at a right angle for a month, the animal would exhibit at his death some years later a highly developed

bursa over the bony protuberance nearly as good as the olecranon bursa on the uninjured side, and better than that of the injured limb. As I have reason to know the meticulous vigilance of this professional and expert humanitarian I hasten here to say in advance that I do not recommend this experiment, not because it would not be entirely justifiable, but because nature herself in the highest Primate has produced many undesigned experiments of nearly equal value, as I hope to show.

Bursæ Described.

Broadly considered a bursa is a sac lined by synovial membrane, and an extreme example of the simplest form in which it is found may be said to be that of the condition found in a domestic dog. Under its skin, except on such regions as the snout, the tail and the feet, there is hardly a place where a bursal surface does not exist. Here and there trabeculæ may divide the great sac imperfectly, but from the protective and selective point of view this mechanism under a dog's skin may be compared to the oil with which an Indian criminal lubricates his naked body so as to elude capture. To us who are too familiar with dog-fights (to which the Hon. Bertrand Russell likened the recent Great War, as we all remember) and who know how much noise and ferocious attempts are made by the warriors to bite one another, and how little success they achieve, the beautiful adaptation of nature in the dog far surpasses that of the Indian criminal. Indeed the latter may well have been suggested by the former.

Between such a simple and undifferentiated bursal surface as this and another such as the small but essential bursa under the tendo achillis there are endless variations adapted to particular uses and regions.

The description of bursæ given by Macalister is too clear and good not to be given in his own words.¹

“Synovial membranes are found either as the lining of joints, or as *Bursæ*, which are closed sacs (*a*) between contiguous soft parts, or (*b*) beneath soft parts which glide tensely over a bone. Bursæ are formed around and beneath tendons in the neighbourhood of joints; and the hard part on which the tendon plays is often invested with a layer of cartilage over which the synovial membrane does not extend. When they completely surround tendons, as in the finger and toes they are called *thecae* or sheaths, and the tendons are connected to the sheaths by synovial reflections. Sometimes

¹ *Text Book of Human Anatomy.* A. Macalister, 1889, p. 48.

bursæ lie between exposed areas of skin and projecting bony points, such as the patella, olecranon, ankles, etc.

“Their (synovial) membrane differs from the synovial membrane of joints in not having so continuous or definite an endothelial lining; indeed, while some bursæ, such as that beneath the ligamentum patellæ, have a more or less regular lining of regular endothelium, others have only elongated connective cells forming an imperfect lamella, and there are all possible gradations met with between the regular saccular bursa, and a loose meshwork of areolar tissue of which the bursa is only a specialisation. Bursæ may be (1) subcutaneous (2) subfascial (3) between two tendons, or (4) between tendons and subjacent ligaments or bone. Of these, some communicate with the neighbouring joints always, some occasionally, and some never. Bursæ underlying parts which have an extensive range of motion are *unilocular*, with a single cavity. Bursæ spread over an extensive surface, and whose walls move but little on each other, are often divided by imperfect fibrous septa, and are called *multilocular*. Almost all the lesser bursæ are unilocular, most of the subcutaneous bursæ are multilocular.”

Now if one were not engaged upon such a problem as that of initiative in evolution and in trying to give examples of it there would be no Gordian knot to cut, and the condensed statement of Macalister might be simply taken as an accepted account of the manner in which reading between the lines a bursa is formed in the animal body. But, when an hypothesis such as the present is in question, one may not cut the Gordian knot in this way, and must produce briefly certain observations of the process, not only those known in man by anatomists and surgeons but also some found in lower Primates.

Human Bursæ Enumerated.

The following is a list of bursæ in man of which some are normal or always present, and others which are both occasional in their appearance and often imperfectly developed.

Front of Neck.

- (A) One in front of the pomum adami.
- (B) One in the thyro-hyoid space extending to the under surface of the hyoid bone.
- (C) One beneath the sterno-hyoid muscle.
- (D) One above the hyoid bone.

Pharynx. A small central pit constituting a single bursa the *bursa pharyngea*.

Behind the angle of the lower jaw. One.

On the symphysis of the chin. One.

On the Acromion process. One.

Beneath the deltoid and the acromion process, one large bursa often opening into the shoulder-joint.

Elbow.

(A) One over the olecranon.

(B) One occasionally over the inner epicondyle.

(C) One over the internal condyle of the humerus.

(D) One over the external condyle of the humerus.

(E) Small one between the biceps tendon and the head of the radius.

(F) Often a second bursa which separates the tendon from the oblique ligament crossing it.

Wrist.

(A) One over the styloid process of the radius.

(B) One over the styloid process of the ulna.

Hand.

(A) One over each of the metacarpo-phalangeal joints.

(B) One over each of the phalangeal joints.

Region of hip.

(A) One over the anterior superior spine of the ilium.

(B) Large one between the great trochanter and the gluteus maximus muscle.

(C) One between the gluteus medius and the bone.

(D) One between the gluteus minimus and the bone.

(E) One between the psoas and iliacus muscles often opening into the hip-joint.

Thigh.

(A) One over external condyle of the femur.

(B) One over internal condyle of the femur.

Knee-joint. The prepatellar bursa.

(A) Between the skin and superficial fascia at the lower edge of the patella there is often a small subcutaneous bursa.

(B) Beneath the superficial fascia over the fascia lata there is always a large interfascial bursa, intersected by smooth fibrous bands extending downwards over the upper part of the patellar ligament.

(C) One still deeper between the deep fascia and front of the bone there is a layer of lax connective tissue.

(D) Sometimes a third or deep subfascial bursa.

“These bursæ over the knee-joint appear in foetal life and vary in size in persons of different occupations, being often large in housemaids and carpet-nailers, and often communicating with each other.”¹

(E) Occasionally the upper part of the synovial pouch of the knee-joint is shut off from the general cavity and forms a separate bursa beneath the extensor muscles. It always communicates with the knee-joint though originating independently.

In the Ham.

- (A) Large bursa between the inner condyle of the femur and the gastrocnemius muscle, often opening into the joint.
 - (B) A smaller one on the outer side.
 - (C) One between the biceps tendon and the external lateral ligament.
 - (D) One between the semimembranosus
 - (E) One between the popliteus
 - (F) One between the sartorius
 - (G) One between the gracilis
 - (H) One between the semitendinosus
- } and the bone.

Tibia.

- (A) One over the tuberosity.

Ankle.

- (A) Over both malleoli.
- (B) Between the tendo achillis and the os calcis.

Foot.

- (A) Over plantar surface of the great toe.
- (B) Over plantar surface of the little toe.
- (C) Over the dorsal surfaces of all the phalangeal joints of the toes.
- (D) Over the dorsal surface of metatarso-phalangeal joint of the great toe.
- (E) Over the plantar surfaces of the metatarso-phalangeal joints of all the toes.

I calculate that there are at least fifty-two separate bursæ (about one hundred on the two sides of the body) in the normal or fully developed state, though of these many will be found either absent or with very little of the full structure of a bursa. One small but significant point may be referred to here. We are all familiar

¹ Macalister, p. 488.

with the prominence of the knuckles of the hand and the very efficient bursæ which cover them, but most persons do not recognise that the foot has no such knuckles (or prominent metatarso-phalangeal joints) and no bursæ over these joints, except that of the great toe which happens to be very much more exposed to friction and has a much greater range of action than the other four metatarso-phalangeal joints. This might be called by some persons a beautiful bit of adaptation *for* locomotion and by others an equally admirable bit of adaptation produced *by* locomotion.

Examination of Two Still-born Children.

Some further light may be thrown upon the human bursæ by an examination of two still-born children I dissected in 1908 in Lewisham infirmary, and give here the results as to the more important subcutaneous bursæ.

Male Child: full term.

Shoulder: bursæ under acromion processes absent.

Elbow: (bursæ over outer condyle of humerus present.

(„ „ inner „ „ absent.

(„ „ olecranon both present.

Wrist: bursæ over styloid process of ulna present.

„ „ „ „ of radius present.

Hand: bursæ over metacarpo-phalangeal joints D 1 absent,
D 2, 3, 4, 5 present.

bursæ over phalangeal joints, first set present,
second set absent.

Hip: bursæ over anterior superior spine of the ilium both
absent.

Knee: prepatellar bursæ well-developed.

Ankle: bursæ over both malleoli present:

bursæ beneath tendo achillis well-developed.

Great toe: plantar bursa present.

Little toe: plantar bursa absent.

Toes: D 1 (great toe) bursa over metatarso-phalangeal
joint present.

D 2, 3, 4, 5 bursæ over metatarso-phalangeal joints
absent.

Bursæ over *Phalangeal joints*.

D 1 present.

D 2, 3, 4, none over either of the phalangeal
joints.

D 5 bursa present over the first and absent
over the second phalangeal joint.

This example of a still-born, but otherwise normal infant illustrates well the previous statement that certain bursæ are congenital and others of less functional importance are formed after birth. Whereas the olecranon, wrist, patellar, ankle and tendo achillis bursæ are fully formed, those under the acromion processes, one of those of the condyles of the femur, and the digits of the hand, those over the superior anterior spines of the ilium and those of the foot are little if at all developed in this case.

Another still-born child at seven months was also dissected and this had well-formed prepatellar bursæ, scanty ones over the olecranon processes, also over the small joints of the hand and foot where they were difficult to isolate and over the malleoli they were only slightly developed.

A foetus in spirit I examined and found no commencement of a prepatellar bursa.

Examination of Living Primates.

Anthropoid Apes.

Eight of these I examined during life at the London Zoological Society's gardens in 1908, four *chimpanzees*, two *orangs* and two *gibbons*. These afforded the opportunity of ascertaining by means of touch the presence, and in a minor degree the size and efficiency of the main subcutaneous bursa, just as one can do this in a human subject. The *chimpanzees* were A, aged thirteen; B, aged seven; C, aged three; and D, aged two-and-a-half years; the *orangs* E, aged thirteen; F, aged three years; the *gibbons* G and H both two to three years.

These eight specimens possessed good examples of the leading subcutaneous bursæ over the olecranon process, the styloid process of the ulna, the patella and both malleoli.

The smaller and less definite bursæ gave the following results.

Chimpanzees.

A. *Hand.* Bursæ on all the metacarpal and first phalangeal joints; none on the second phalangeal joints of D 2, 3, 4, 5.

Foot. Bursæ well marked on the five metatarsal first phalangeal joints; none on D 2, 3, 4, 5 joints. but one on that of D 1. None found on second row of phalangeal joints.

B. Moderate development of bursæ on metacarpo- and metatarso-phalangeal joints of D 1; doubtful on those of D 2, 3, 4, 5.

On hand and foot first phalangeal joints, bursæ present, on second row absent.

C and D were similar.

Metacarpo- and metatarso-phalangeal joints, none in C and scanty in D.

No bursæ on any phalangeal joints of hand or foot.

Orangs.

E. Metacarpo- and metatarso-phalangeal joints, bursæ ill-developed, first row of phalangeal joints of hand and foot moderate, second row none.

F. Metacarpo- and metatarso-phalangeal joints more marked than in E., and well developed on all phalangeal joints.

Gibbons.

G. Metacarpo- phalangeal and metatarso-phalangeal joints poorly developed on D 2, 3, 4, 5, and none on those of D 1. Absent on all phalangeal joints.

The digits of the gibbons were very long and evidently efficient in action, but were never flexed to any great degree.

Dead Specimens.

I also examined the hands and feet after death of certain lower Primates in 1909 :—

H. *Hapalemur Griseus*.

I. *Hapale Jacchus*.

J. *Cercopithecus Callitrichus*.

K. *Cercopithecus Mona*.

L. *Macacus Rhoesus*.

Hapalemur Griseus H. *Hands*. No bursæ on styloid processes of radius and ulna, and no localised bursæ on any metacarpo-phalangeal or phalangeal joints.

Feet. Bursæ under tendo achillis small but distinct. Present over both malleoli.

Metatarso-phalangeal joints D 1, 2, 3, rudimentary D 4 and 5 absent.

First phalangeal joints of D 1, 2, 3, 4, rudimentary absent over D 5.

Second phalangeal joints absent on all digits.

Hapale Jacchus I.

Hand. Lower end of ulna, which is very prominent, a bursa present, over end of radius, *which is much less prominent*, absent.

Metacarpo-phalangeal joints, present in all.

First phalangeal joints, which are prominent, present in all digits.

Second phalangeal joints absent in all.

Foot. Bursa under tendo achillis and over both malleoli.

Metatarso-phalangeal joints absent on D 1; present on D 2, 3, 4, 5.

First phalangeal joints, present in all.

Second phalangeal joints, absent in all.

Cercopithecus Callitrichus J.

Hand. Dorsal surface of the whole hand shows no localised bursæ, only a loose areolar tissue under the skin.

Styloid processes of radius and ulna no bursæ.

Foot. Dorsal surfaces over the whole foot similar to that of the hand.

Bursæ present over both malleoli.

Well-formed small bursæ under tendo achillis.

Cercopithecus Mona K.

Hand and Foot. Dorsal surfaces similar to those of J and similar loose areolar tissue over styloid processes of ulna and radius.

Bursæ over both malleoli.

Well-formed bursa under tendo achillis.

Macacus Rhoesus L.

This specimen showed more examples of bursæ than the two of *Cercopithecus*.

Bursæ present over styloid processes of ulna and radius, also over metacarpo-phalangeal joints.

Bursa well-marked over malleoli and under tendo achillis.

Bursæ present over metacarpo-phalangeal and metatarso-phalangeal joints.

No bursæ over phalangeal joints.

Further Undesigned Experiments.

The preceding facts as to the natural history of bursæ in man and some lower Primates, even if they stood alone, are enough to produce conviction as to the manner in which bursæ of all degrees of perfection are formed by function, and point to the origin of the initial stages of these structures. But they do not stand alone, for in man there have been carried out certain undesigned experiments in a similar direction, comparable to those described in the sections on direction of hair and arrangement of papillary ridges. These

demonstrate the fact that frequent friction of skin over a hard surface has the power of producing adventitious bursæ in regions where they are not found in the normal state.

These adventitious bursæ are the following :—

In the first place certain normal bursæ in important situations are frequently so much enlarged by the constant irritation of pressure and friction that they become considerably enlarged. This enlargement may go on to definite pathological changes and thus come under the care of surgeons.

They are Prepatellar bursæ—"housemaid's knee."

Olecranon bursæ—"student's elbow" and "miner's elbow."

Tuber ischii bursæ—"weaver's bottom."

These may be called "occupation-bursæ" and may be classed with three other well-known adventitious bursæ which are formed on the shoulder in "deal runners," on the scalp in "fish porters" and in the back of the neck in Covent Garden porters, known as a "hummy." Entirely new bursæ are formed also over the cuboid bone in talipes equino-varus, over the internal condyles of the femur in bad cases of knock-knee from friction of one joint against the other, over the prominent vertebræ in a humpback. A structure closely resembling a bursa and arising from similar causes to those producing adventitious bursæ is found in unreduced dislocations or ununited fractures.

A small example of an adventitious bursa came under my notice. A woman, E. L., aged 49, had remarkable enlargement of the metatarso-phalangeal joint of her great toe of the left foot, and over this joint was formed a well-marked bursa on the dorsal surface. The right foot showed a much less prominent joint and only a very slight development of the corresponding bursa.

This instance of a bursa-like structure being produced in unreduced dislocations and ununited fractures suggests the conception which I here propose, but do not attempt to verify that *all joints in all animal forms from the lowest up to man have been evolved in a manner to which this pathological experiment may give a clue.*

A remarkable case reported by Sir William MacEwen in the Royal Society's *Phil. Transactions*, Series B, Vol. 199, pp. 253, 279, is worth referring to in this connection. It was a case of a growth of bone in muscle connected with an old injury to the thigh of a man 38 years old, and healthy. At the operation performed by the author of the paper the tumour was found to be movable, partly attached to the fascia lata of the thigh, and the upper part of the

tumour moved on the lower. It was found that the tumour consisted of two parts, the upper three-and-a-half and the lower seven inches long, altogether a mass about ten inches in length. Muscular bundles of the vastus externus were included in this ossific formation, one passed through a tunnel in the bone through which it worked, and the sides of it were polished. *At the point where the newly formed bone came in contact the surfaces fitted each other and were polished as if they were covered with cartilage, and were here surrounded by a capsule.* (Italics not in original.) This fibrous covering when opened was seen to contain a thin serum, which, though not of the consistence of synovial fluid, still aided in lubricating the polished surfaces as they played over one another.

A similar case was reported also by Dr. C. Paterson, surgeon to the Glasgow Royal Infirmary.

A very interesting address by the Hunterian Professor, Mr. Jonathan Hutchinson, was given in February, 1917, on Duputryen's work, especially in the discovery of the cause and treatment of the contraction of palmar fascia known by his name. Professor Hutchinson described his method of curing this by the removal of the head of the first phalanx, and showed excellent results and evidence of the formation of a perfect new joint to take the place of the old distorted one, and the fingers were as efficient as in the normal state in the exercise of flexion. He gives photographs of the hand some months after the operation showing it to be capable of easy and full extension as well as of flexion. This again agrees well with the cases of Sir W. MacEwen and Dr. Paterson of the formation of a functional joint *by* use and habit.

Another distinguished Hunterian Professor A. Keith, also gave two lectures in January, 1918, on the "Introduction of the Modern Practice of Bone-grafting," which, in its modern form, he assigns to the credit of Sir William MacEwen. He lays great stress on the important work performed in such cases by the osteoblasts without whose living and formative action these results could not be obtained. He explains how necessary it is that these living elements should be stimulated into action by *work*. They thrive only so long as they have work to do. Another surgeon, Ollier, "wondered why the fragments of bone which he had succeeded in raising from slips of periosteum planted beneath the scalp or amongst muscles ceased to grow and tended to disappear. These bony grafts withered because they were not subjected to the strains and stresses which rouse the activity of osteoblasts." MacEwen, "by a fortunate chance, planted his tibial grafts in a situation where they soon became subjected to muscular strains and stresses.

In a short time bony fragments gathered from the legs of six boys became intrinsic parts of the humerus of a seventh ; from the moment of primary union the bone cells of the graft were brought under the stimulating impulses of the biceps and triceps. Osteoblasts are the obedient slaves of muscles ; *muscular dominance is their breath of life.*" (Italics not in the original.)

"Wolff was the first to devote thirty years of constant work and observation to prove that the shape and structure of growing bones and adult bones depend on the stresses and strains to which they are subjected. By altering the lines of stress the shape of a bone can be changed."

Wolff's law is simply this : "Osteoblasts at all times build and unbuild, according to the stresses to which they are subjected."

Professor Keith says further : "We are driven, as I have pointed out in a previous lecture, to look for the primary cause, not in the bones, but in the muscles, particularly in those which are tonically and constantly in action so long as we are standing."

A terse expression of Wolff's law is quoted from Dr. John B. Murphy, of Chicago : "The amount of growth in a bone depends upon the need for it."

A remarkable illustration of a similar process is given in the construction of sponges by the scleroblasts and it is stated : "The soft walls of this sponge are constantly exposed to the force of moving waters, and we shall see that the spicule-builders—the scleroblasts—are endowed with the same properties as osteoblasts—the powers of fashioning and depositing the elements of the skeleton so that the sponge can best resist the forces to which it is habitually exposed."

One more important quotation from this lecture will suffice. "No one who has watched the behaviour of scleroblasts and marked the design in their workmanship can doubt that they have acquired certain characteristic qualities, chief of which is a sensitiveness to vibrations—to stresses. We see them build the same form of spicules as their ancestors, and therefore must suppose that their building quality is a gift of inheritance. We see them alter their mode of building as stresses change ; we must therefore suppose that their inherited powers can be changed by the circumstances under which they work."¹

In regard to the action of the scleroblasts of sponges I have only to point out that the cautious words of Professor Keith on the

¹ Hunterian Lecture on "The Introduction of the Modern Practice of Bone-grafting." Royal College of Surgeons of England, January, 1918. Reported in the *Lancet*, February 9th and 16th, 1918.

treacherous ground of inheritance amount to the very same conception of personal selection and inheritance as are involved in the term "educability" of Sir E. Ray Lankester. Whether or not in the case of sponges this be a complete account of the matter it at any rate is a very important piece of evidence, if valid, for selection. Whether or not further it is a piece of evidence for a Mendelian factor implicit in the primordial sponges and released by some loss of inhibiting factors, as Professor Bateson would probably claim, is another and far more imaginative conception. The mere neo-Lamarckian with the aid of personal selection fails to see any difficulty in realising the wonderful process described by Professor Keith.

An apology must be offered here to the patient reader for the introduction under the heading of the "Evolution of a Bursa" of the apparently alien subjects of bone-grafts, artificial new joints and sponge-spicules, but I have hazarded the guess that all joints in all animals have been fashioned—"forged by the incident of use," to employ a fine phrase of Professor Macdonald's in another connection—in slow but intelligible ways by use, and that in them, as elsewhere, function has preceded structure. This arose so simply out of the story of the bursæ that I ventured to digress as aforesaid rather than make it the subject of a separate section.

The Significance of the Proceeding.

The foregoing slender contribution to the comparative anatomy and physiology of bursæ is sufficient to show that at certain important and "critical" points in the mammalian anatomy, efficient bursæ are always present. One cannot indeed conceive the function of the parts involved being carried on at all without these ingenious contrivances, and no doubt can exist that in certain of the leading bursæ selection guides and guards, while use and habit maintain them. Over such as these "dominance" or the appearance of mutations might perhaps be supposed to preside, and possibly some useful statistical results might arise from their study from these points of view. But, between these major bursæ in man and lower Primates and the undifferentiated sacs which hardly deserve the name of bursæ, there is a perfect little host of insignificant structures, which at the first attempt at dominion over them on the part of Mendel or de Vries would hoist the standard of revolt. These would even refuse allegiance to Personal Selection under the persuasive banner, "Educability," which however valuable elsewhere, must stand aside in this little province of Nature. I have thus attempted to "Lyell" this body of facts. Basing the state-

ment on an analysis of a considerable mass of small facts which no one disputes I claim that the modifications drawn from normal anatomy on the one hand and on the other adventitious structures, produced by acknowledged mechanical forces, are examples of the transmission of modifications, and illustrate the mode of formation of certain initial variations. In other regions where Plasto-diëthēsis, as I conceive it, is at work in producing adapted organisms, there may be included in the hyphenated area certain factors of heredity, Mendelian, mutational and others, but not in this group. This is merely an assertion of an opinion though I submit that there is good evidence for it. Not even the hardest hearted Weismannian, Mendelian or mutationist, and not even the biometrician can refuse to this poor little province the required time and mechanical forces, and, unless an opponent can offer some explanation more consistent with the facts than that here offered, the proof of causation is as sound as that shown in the larger one of the direction of hair.

CHAPTER XXI.

THE PLANTAR ARCH.

THE principle of Lyell cannot be applied to this section of my subject for it is unique in the animal world. There is here a simple compilation of facts such as the medical schoolboy is supposed to know, and only requires for its setting forth the valuable expert knowledge of our predecessors in anatomy. It is indeed a pedestrian chapter.

Man alone possesses this mark of a high lineage, and it adds point to Shakespeare's description of man as "paragon of animals," and Huxley's "a superb animal, head of the sentient world." For winning this integral part of a perfect walking-foot man must stoop to conquer; he must descend from the trees in order that he may have life and liberty; whether he bears the ancient surname of Tarsius or the more honoured one of Pithecus matters not. Names had not in those early times usurped that tyranny over man's mind which they have done among his modern descendants. He came into that terrestrial kingdom which was to be his own with many a limitation, but with the promise and potency of an unexampled evolution, when he assumed more fully the erect posture and saw that his inheritance was very good. Neither then nor since has he ever reached the fleetness of foot of the Thibetan wild ass, the astonishing sense of smell of the dog or horse, the keen sight of the hawk, or the climbing power of that simian family upon whom he turned his back as on a poor relation. He became *par excellence* the walking biped of earth, as, even with greater value to his mastery of the world he learned to talk in articulate language. A walking animal and a talking animal, with vast stretches of time for training these new powers of his, he became modified into the variegated human stocks, black, yellow and white, that now inhabit the earth.

A Crumbling Arch.

A digression, I hope, will be pardoned here before the value and beauty of the plantar arch and its mode of forging are described, and it is possible the latter may add some force to the former. Scientific (or, must I say ?) semi-scientific writings are not concerned

with the snobbishness of much of the pride of birth which still survives among us. But I would indeed think myself to be doing "my bit" if I could induce the present generation of young women and men to think highly of their plantar arches, nobler evidence of a "good" family than soft fair skin, taper fingers, Grecian nose, slender waist or that hair of which the decaying line of the long-haired kings of old France were too proud. For one reason or another, probably analogous to those for which he has lost so much the vigour of his hair of the scalp, or his dwindling wisdom-teeth and shrinking little toes, in other words, racial degeneration, modern man seems to be losing his plantar arch. For about three years I have made careful but saddening study of the ankles and feet of young women, and have embodied it in a variety of journals. This study has included about two thousand examples in young women of incipient or advanced flat-footedness as revealed, nay, flaunted before us in our towns and villages. This revelation has been offered by women's shortened skirt, so that one can now note for oneself the ugly and disabling ankles and feet in the streets of any town, without the complicated business of a surgical examination. Such an examination, as it happens, and as it is usually undertaken, serves only to show a moderately advanced degree of this deformity, indeed, just so much as induces a patient to go to a doctor for relief of pain or obvious deformity. This is wholly insufficient for the study of a defect which in the various degrees of its development affects nearly 90 per cent. of all youngish women so far observed and noted. The doctors may—or may not—cure this evil, but they are not likely to find time even to discover during their strenuous lives, the great spread of this physical defect. But the merciful ukases of fashion, from Paris or elsewhere, and the obvious benefits, for once, of a fashion, are so powerful that the short skirt has remained with us for several years past and does not seem likely to go. I can only hope it will last until women who lead their sex in these days become ashamed of the feet of their sisters and their own, and make a forcible attack upon the Health Minister or Minister of Education, or both, so that systematic foot-drill in all elementary schools may be established. No other means than this, added to improved general health, can be conceived as able to correct so widely spread a deformity. I do not desire to be considered as making an attack on the bodily charms of women, for whose multifarious attractions I yield to none in sincere regard. But here is the revelation, here are the cases walking unashamed before us, and if the skirts *should* lengthen again and cruelly hide up the evil, no one will be induced again to take up the

unpopular attitude of saying that nearly all young women have feet that are deformed and ugly and, therefore, more or less inefficient. There is, alas ! only too much reason to know that the evil is great among the better class, even of boys, for in 1919 Captain Coote said publicly at a Schoolmasters' Conference that fully 30 per cent. of the new boys entering leading public schools had flat-foot, and Captain Coote, the highest exponent of physical training in the Navy, knows a flat-foot when he sees it. The measures here suggested in connection with the feet of women have the great merit that from them boys and girls will alike benefit.

Non-Arboreal Man.

Many problems faced non-arboreal man as he descended from the trees to claim his suzerainty and place of toil. Not least among them was the question of methods of protection against the terrible creatures among which he was to live. Their production must needs be slow, and for him to meet by "direct action" with weapons invented *ad hoc* the fierce large carnivora and clumsy but dangerous dinosaurs would have proved highly dangerous. Too long had they been in possession of his Canaan, and he could not cross his Jordan, walk seven times round their Jericho, blowing with trumpets of rams' horns, and on the seventh day march in and "consolidate his position." He had first to do what his descendants have always been bound to do ; he had to learn to walk terrestrially long before he could think and live imperially. Sufficient for him was the evil of his day, and, as an old arboreal denizen he had much to learn and not a little to unlearn ; and we know from the prehistoric pictures of his own doings and trophies, that he did in course of ages learn to walk, run and jump with variety of step and efficiency unknown in any other Primate group. We can ask, and we can but supply speculative answers as to the details of *how* he did it, but somewhere and at some time he learned first to become as good a walking animal as later he became a talking one, and some at any rate of the steps of the process are plain for all to read to-day.

How the Arch was Built.

Did I not know something of the severity of the judges in such a Court of Appeal as we are facing in this case and of the opposing counsel—of the jury I have less fear—I should be disposed to settle on a half-sheet of note-paper the problem that non-arboreal man settled ages ago for himself on the ground, by a familiar saying. It really meets the non-scientific mind which is not weighed down by what Captain Marryat used to call "top-hamper,"

to answer *Solvitur Ambulando*. But I hear judges and counsel both saying "This will never do," and must address myself to opening up the case.

If an adventurous gorilla and his mate, whom we may call gorilla Columbi, had long ago made a bid for a life completely terrestrial rather than partly arboreal, it is difficult to imagine how the feet of this pair could have failed to adjust themselves and their separate tarsal elements to a better if rudimentary form like that of man, and that their progeny would not have followed or improved upon this. Professor Keith,¹ in his work referred to, and Professor Wood Jones in *Arboreal Man*, have much to say on the evolution of man's foot and arch, and I mention this *ab initio* so as to be free from any supposed claim to originality which is apt in the present extended range of scientific progress to be as damaging to a man as for him to proclaim his honesty or a woman her virtue. And I also formally grant to the Mendelians and Mutationists, without offence and with some possible relief to their minds, a period of leave from this poor trench-warfare—*Plasto-ditēthēsis* will not be obliged to call in at the place of its hyphen any reinforcements from these of the higher command.

The assumed precursor of our human walker was probably more highly evolved in his own special line than the real ancestor, but we have so little yet of discoveries of whole skeletons of earliest man that the bodily structure of gorilla C. may fairly be taken as a starting point, indeed he is for this purpose a valuable lay-figure, almost artistic for once, on which may be draped the following story of the making of an arch. The ultimate verdict, which word I use in the old English sense of a "true saying" rather than the most recent declaration of those who "ride on white asses and sit in judgment," does not therefore invalidate the verisimilitude of this picture. One may go farther and affirm that, given certain anatomical and physiological facts in an earlier Primate stock, which marvellously resemble those of modern man, and it must follow as the night the day that his more primitive physical basis employed in a new mode of progression, that is of terrestrial walking on two feet, will be converted by use and habit into the construction of such new formations as will best agree with the new style—in other words, in this instance, a plantar arch.

An Unique Phenomenon.

That a plantar arch is peculiar to man is a matter of fact, and Lydekker in the *Royal Natural History*, Vol. I., p. 41, says

¹ *Human Embryology and Morphology*.

of the gorilla's foot incidentally "there is no sort of resemblance to the human instep in the whole foot," and Professor Keith in the work referred to "the arch is a human character." One may see this for oneself in living apes and monkeys and in the wonderful series of drawings of apes in all kinds of postures in the *Royal Natural History*, and indeed in the feet of dead apes and monkeys. All Primates other than man walk on a flat sole.

Equipment.

Our adventurer starts with the following equipment of tools for making his arch as he learns to walk entirely on the ground which it must be remembered he can only do by unlearning *pari passu* his highly cultivated power of grasping with his foot. The old and the new cannot flourish together. The evolving foot of man is an example of a slow change in the function of an organ and consequent modification of certain structures in it. He walks with his feet turning in, or in the axis of the leg; his great toe is not in this axis but may even lie at a right angle to the foot; he rests weight on his heel and even more on the outer border of his sole, and thus the sole of one foot turns more or less towards the other; and he puts a good deal of weight on his toes which are frequently doubled over; and his gait, though erect, is never completely so, and is clumsy in appearance.

Bones: his heel-bone is relatively long and pointed and slightly arched below; the bones of his great toe are short and thick, and the other four toes relatively long and slender. You can see at once it is not primarily a walking foot. Any active boy of twelve could give him points and a beating in a race for life in the open. Further, his foot shows a much larger proportion of the whole foot in front of the end of the great toe than is ever seen in man. The *ligaments* which bind the joints of his foot together, while the muscles play upon them, are little different from those he will require for the girders of his arch, except for such a throwing out of slips, and shifting under the stresses and strains of such walking as his new gait involves.

The *muscles* of his leg and foot are the most important by far of his original equipment with which to set about making his arch: he could no more do this out of his present muscles than a Hebrew could make bricks without clay. It is these variable and plastic structures which are most readily adapted by use in a fresh direction or increased degree. He has the great flexors of the ankle and foot in his poorly-shaped calf (this feature might be adduced as a human character and studied in this manner if it were not of so elusive

a nature) and the long flexors of his four outer toes, the special long flexor of the great toe, which in his case does not of course act in the axis of the other metatarsal bones. He is lacking here in the special detached portion of the *flexor accessorius*, which eventually becomes of use in maintaining the arch, between the heel-bone and the tendons of certain digits. He has, in a measure, the *oblique adductor* muscle of the great toe and the *transverse adductor* muscle, more for future use perhaps than of much present value. Like all apes and monkeys he has a *peroneus longus* with its tendon passing across the sole from the outer border to the base of the great toe and a *peroneus brevis*, both of them for everting the foot and supinating it. But here again he is lacking, for he has no little *peroneus tertius*, which Professor Keith speaks of as a muscle "peculiar to man" and "a special everter of the foot"—a muscle passing from the tendons of the *extensors* of the toes and inserted into the little toe. He has also the *tibialis anticus* and *tibialis posticus*, the latter which flexes the ankle on the leg, and the former which also flexes it and everts the foot; he has also the special *extensors* of the toes.

This enumeration of the bony, ligamentous, and muscular possessions of gorilla C. is enough to show that, though he has little of new tools to make, he has to modify greatly those he has learnt to use so well, so that one can almost hear him echo the words of David to Saul as to his new armour.

The problem of an arch remains to be solved by eversion instead of inversion of the foot, growth in all directions of the heel-bone, and the enlargement and straightening of the great toe, and the "setting" of the foot in a certain degree of pronation and over-extension.

Description of the Arch.

The plantar arch is double, but the longitudinal one must be chiefly considered here. It lies under the concave roof of the tarsal bones, seven in number, and the metatarsal bones, and rests in a well-formed foot in front on the heads of the latter, and behind on the inferior surface of the heel-bone. The *astragalus* alone of these bones in contact with those of the leg, acts like a washer to the ankle joint, and has no muscles attached to it. Three more of the *tarsal* bones need reference: these are the three *wedge-shaped* bones which have their bases on the dorsal and their apices directed towards the plantar surface. With such a set of bony tools as this, all the requisites for an arch are at hand. Let the half-tree, half-ground walker become a complete ground-walker, and in the first place the manifest increase of the action of the flexors of

the leg will pull to an unusual extent on the *tendo achillis* and heel-bone, leading, in accordance with a well-known law, to steady enlargement of the parts near to which it is attached. The greater amount of weight thrown henceforth on the heel tends in just the same direction, indeed, to general enlargement of the whole bone. The *astragalus* being in No Man's Land, so to speak, takes less part in the change than any other tarsal bone. The *wedge-shaped* bones are exactly so constructed as to retreat a little in a dorsal direction as the modified walking increases under the action of certain muscles which will later be mentioned. This, in conjunction with the projection backwards of the heel and the general growth of the bone, permits, as far as the bony parts go, a gradual hollowing out of the originally flat plantar surface, and the increasing eversion of the foot places more weight on the front pier of the arch, that is, the heads of the *metatarsal* bones. The squeezing-up process of the smaller *tarsal* bones contributes also to the formation of the transverse arch.

The *ligaments* need no new invention on his part but only a more human degree of development, and in particular the *calcaneo-navicular* ligament and *internal lateral* of the ankle undergo in the human foot great development, and the long plantar ligament, originally part of the tendon of the *gastrocnemius*, comes in to the aid of the arch and goes to bind it together, so that these humbler structures follow in the wake of the changing and enlarging bones.

The plantar fascia, though a powerful protective armour for the deeper parts of the sole, cannot be held to enter into the formation of the arch. The *initiative* in this process lies with the muscles, and, even if neither gorilla C. himself, nor his descendants, had altered the muscles of his foot and just given up climbing for walking, there were muscles strong enough and appropriate for modifying very profoundly his simian foot, though he might not have arrived at an arch. He or they might have become long-distance walkers, but never sprinters.

If the sole of the dissected foot is observed it is seen that the plantar arch lies approximately over a triangle of which the base is formed by the *transverse adductor* muscle of the great toe, across the heads of the metatarsal bones, and the two sides by the *oblique adductor* of the great toe and the *short flexor* of the little toe. It extends, of course, somewhat further back under the heel-bone, but this is its highest part.

In the changing foot the *tibialis posticus*, which was originally a flexor of the metatarsal bones, obtains a secondary attachment

to the *scaphoid* bone, and the *tibialis anticus* becomes inserted anew into the internal *wedge-shaped* and metatarsal bones. "Both of these muscles, thus modified, help to maintain the arch of the foot. So does the tarsal part of the tendon of the *tibialis posticus*." (Keith).

The three *peronei* muscles, especially the new *peroneus tertius*, attached to the little toe, are called in by increased walking to redress the balance of forces in the foot and produce that eversion, with some supination, which is essential to the arch. No arch was possible till these muscles came into some preponderance of action over the *flexors*, so beloved of gorilla C. The *short flexor of the digits* becomes modified so that its attachment to the tendons of the *long flexors* in the sole has its *origin* completely transferred to the heel-bone in man (Keith). "It can thus act more powerfully in maintaining the arch," and finally the *flexor accessorius*, a muscle which cannot fail to surprise the dissector when he first penetrates into the deep layer of muscles of the sole, and which is a detached piece of the *long flexor of the great-toe*, becomes especially well-developed and helps to maintain the arch.

The order of events then is : first, increased and altered muscular function ; second, growth of bones and adjustment ; third, binding together of these by new or modified ligaments. If it were possible to separate in this way the age-long formation of such a living tool as the human foot, this is the order in which alone, I submit, the sequence of events can be placed. It is a convenient, because simple and plain example of initiative in evolution, and I cannot say how much I owe to Professor Keith's teaching on the subject.¹

¹ It is not sufficiently noticed by some writers how important is Professor Keith's teaching as to the maintenance of the arch by muscular action rather than ligamentous union. And it is a very practical matter from my own point of view in connection with the prevention of flat-foot in the young. If indeed the poor deformed feet of the sufferers can only be corrected by attention to the lowly-organised ligaments, and the muscles will not avail, I can but add "God help them!"

CHAPTER XXII.

MUSCLES.

A WORK of great value to the biologist has been written by one whose work has led him in the widening path of human physiology and its very title is instinct with meaning. The Integrative action of the Nervous System may not aid the systematist or the student of genetics, but for insight into formative powers, where the former can but record facts and find no interpretation, such a work is of supreme importance. When the plant sealed its fate and enclosed itself in a cell-wall and abandoned a life of movement, it was foreordained that its rival would be that cell and its descendants which could adopt a free life, and that the future of the world would lie at the proud foot of that conqueror who could command and mobilize the resources of a nervous system. And, as we know, it has fallen to man to receive the rewards of this promise and potency of a higher life. If one seeks to understand the steps by which man has arrived at his primacy it can only be by the highway of nervous progress, however much the tracing of certain connecting or collateral paths may throw light on contributing causes. So that man's place in Nature is nearly synonymous with the structural evolution of his brain, as Huxley has shown in his clear and simple manner. Even if man is to remain still an animal Melchisedec for generations to come, or to put it lower, a foundling, no future discoveries that can be imagined will disprove Huxley's declaration, "Evolution is no longer an hypothesis, but an historical fact." And yet if man has become adapted to his world, and, in it, crowned with glory and honour by the unfolding of some original complexity, or as the result of some fortunate mutations in the distant past, the human brain, with its cranial capacity of nearly three times the number of cubic centimetres to that of the gorilla, has been making false claims to a paramountcy over all factors in the wonderful initiative of fresh capacities and their mobilisation for conquest. Nothing less than such a "claim" was understood by the ancients, and, though metaphysics had to supply the lack of anatomy and physiology, it has always been held that mind was lord of matter, and now scientific research has told us why. But no one, even the

most hard-shelled scholastic, can refuse to the brain organ its predominant share in the making of man. This is seen even in the frigid sphere of science by the difference of interest there is shown between any great discovery bearing on the evolution of man, or on some new lower animal form. When Sir. H. H. Johnston astonished zoologists in 1901 by his discovery and proof of the existence of an archaic large mammal which had been interned for an incalculable time in the Semliki Forest, the thrill felt at that historic meeting passed off very soon when the leading British biologist had monographed the Okapi, settled its name and surname and introduced it into text-books. This is never the fate of such as *Pithecanthropus* or *Eoanthropus dawsoni*, or of the more recent genealogical theory and researches as to arboreal man. The call of these studies of man's evolution is felt by all, and the difference in the two branches of biology may account for what must have struck many others, that is the neglect of adding the blue ribbon of science to the honours of the discoverer of the Okapi.

These few trite remarks as to the importance of the nervous system in the making of man have been introduced here, though they bear more closely on the next two chapters, because this importance comes in at every stage of the present treatment of the origin of modifications in muscle.

Anatomists' Views of Muscles.

There is a very strict and austere custom among anatomists, which doubtless is in a measure necessary, of insisting upon following rigorously the homologies of muscles, especially in human anatomy, and in this branch of a greater subject the canons are followed to an extent that surprises the seeker after origins. A remarkable example of this is in a paper by an eminent anatomist, now Professor at King's College, Dr. E. Barclay Smith. It is a paper on the "Morphology of the short extensor of the human fingers."¹ He says "the precise significance of this occasional *extensor brevis digitorum manus* is a matter of considerable interest." He gives four possible interpretations of this unusual muscle. The last, viz., that it is derived from a new muscle-germ alone interests us here because of the remarkable caution and austerity of his remarks on this interpretation. "If an *ext. brevis dig. manus* cannot be regarded as an atavistic anomaly, or as a derivative from any existing musculature, the only way in which its presence can be accounted for is to suppose that it is of entirely new origin—the product of a new muscle-germ.

¹ Anatomical Society of Great Britain and Ireland, Trans., p. 54.

Such an explanation is, of course, the last resort, and all other possible derivations must be disproved before it can be accepted." The physiologist would probably think such an interpretation was the obviously first resort. The same writer discusses at length the homology of an exceedingly rare anomaly among muscles, the *extensor ossis metacarpi hallucis*, and his desire on the one hand to find a missing parent for Japhet, and his honesty and accuracy on the other hand lead him to say "even when it is present, it cannot be regarded as directly atavistic, since it does not represent a normal mammalian tendency." And he adds a gentle but remote suggestion—"Brooks certainly describes such a muscle in *meno-branchus* and *hatteria*—two rare and remote reptiles!" But, lawful and necessary though this be, there must be stages on the path of human evolution where such a method must fail and the anatomists can do no more than hold aloof from theory or speculation, with a certain grim enjoyment of the disputes and difficulties of the genealogists.

Initiative in Muscles.

Initiative in the evolution of muscles clearly occurs somewhere in the stem, and behind the formed expression of an altered habit is the integrating action of the nervous system. This will be by some looked at askance as a *deus ex machinâ* and reckoned as part of the argument from ignorance in a way which recalls Weismann's scorn of Lamarckian factors in germinal selection. I submit that what he and Osborn call "the unknown factor" of use and habit, arising in response to new stimuli meets as no other proposed suggestion does the formation of new muscles. Given a certain fundamental architecture of skeleton and musculature, such as of primitive vertebrates, one can, without doing violence to any known facts, place the formation of new organs of movement in the following order:—

1. Neural changes and habits.
2. Muscular modifications.

3. Consequent modifications of bone. It carries the question no further to say that these are correlated, however loose may be the meaning of that word that is understood. If the prerogatives of Selection within the germ, of segregation of unit-characters and dominance, and of mutations are not unlimited in the construction of organisms, there still remains a sphere of action for the initiating power of the nervous system. Bones grow and change their form in response to increased or altered muscular action on them, and it is necessary to look back a stage further in the story to the neural changes however produced. There have been abundant

opportunities in the long history of mammalian evolution for primitive forms to take a new course of life, and they have done so on an extensive scale. The impulses that have led them may have been started by some "needs" such as Lamarck taught, some change in their surroundings involving new stimuli, or "insults," as Haeckel called them, but the first of the structural stages must have been in the cerebral cortex.

Cross-Roads in Evolution.

The most instructive levels of animal evolution are those where two or more great stocks have diverged from a primitive one. There may have been several factors leading to the division of the early Ungulates into the odd-toed and even-toed groups, of the Carnivora into cats, dogs and bears, the Felidæ into the highly-specialised genera of that intense family, the early parting of gibbons from the common anthropoid stem, and then the division of this line into the three great genera with which we are familiar. Whatever may have been the unknown factors in the environment such as changes of climate and level, geographical isolation, increase of foes, profusion or lack of food, to which these diverging stocks became adapted in their organs and form, in fact whatever we do *not* know, we know this—that in their measure they acquired more convoluted and often larger brains, and the stimuli passing through their receptors into their consciousness increased with an everflowing tide, in volume, intensity and complexity. Many an archaic habit of their race they must unlearn, and it is doubtful if germinal selection would avail in this valuable process of economy as it is held to do in the case of the human little toe.

It may be taken as granted that increasing complexity of brain in their own lines of life did accompany these adventurers of small or large groups. It follows that muscular changes from the original stock would follow neural changes, for movement and activity is inseparable from the animal, and the integrating action of the nervous system would constantly initiate, maintain and establish fresh habits and these be expressed in new muscular structure. Whatever higher uses, as we believe them to be, man makes of his brain, as reflection, reasoning, imagination and association, such were not the new properties acquired by these adventurers. They were very much concerned with hunger and love, and for them "philosophy" did not sustain the structure of their world. But more varied movements of head, trunk and limbs, and greater agility and strength brought them such prizes as were within their reach. This may be only another way of expressing Sir E. Ray

Lankester's conception of educability, which he maintains to be the only acquired character the organism inherits, and it may be therefore assumed to be under the iron law of selection. This must be accepted with the respect due to the high authority from which it proceeds. But such a conception, while it removes a false light in certain regions, sheds no light on the pathway of animal evolution, unless modifications be transmitted, and we can now take it that man does not inherit the power to speak which for incalculable ages he has been learning, nor to write, even though in the days of the early Pyramid-builders and the Sumerians in the plains of Chaldea they possessed the power of writing, nor can a musician's child learn to play an instrument without teaching, or indeed man perform any of his arts and crafts by second nature: so, negatively, this knowledge is valuable, and the neo-Lamarckian must proceed on his quest without anything more than educability to aid him—but it will serve. The fact is that we do not inherit habits or associations as such at all, but the neurones of the grey matter in spine and brain which subserve, direct and control them. Though a fresh neurone or two in the brain of an early ungulate deliberating, so to speak, as to the life he shall take up, whether that of oxen or horses, may be trifling in itself as to immediate value to the animal, it may be to him as much a matter of fate to acquire those microscopic cells as it was to the undifferentiated organism that paused before it sealed its fate as plant. Under the free and enlightened government of the integrating nervous system liberty to express itself to an almost unlimited extent, in accordance with progress, is thus open to the hypothetical adventurers.

When considering such an aspect of the organism as the "choice" between the career of an odd-toed or even-toed ungulate, a cat or dog, a lion or tiger, a gibbon or other of the four anthropoid genera which assuredly was presented to certain groups of primitive ungulates carnivores, felidæ or apes, as historical beings, the vision of the process is sore let and hindered by the limiting force of certain expressions which have been sanctioned with the *imprimatur* of fifty years' high thinking in the realms of high biology. I refer of course to the terms Selection and Evolution which, though they cannot be replaced by better terms, have the power and sometimes have had the effect of impressing on the story of organic existence an aspect of *determinism* which does not allow, for any purposive action of the individual, the working out of its own salvation, on the part of higher forms at any rate. As among nations self-expression has become of late a powerful force in their development, and indeed of individuals, so it may be argued by analogy that the

total experience of an organism, may result in its co-operation in the process of its progress towards higher things. Bergson hints at such a process in organisms, but appears to allow nothing for the individual in his *élan vital*, where the mass alone counts. So if the two binding terms of Selection and Evolution must be granted their enormous power over our thoughts, there must be also a loosing as well as a binding, and we, as well as certain young ecclesiastics in a hurry, may put in a plea for Life and Liberty. Thus is Lamarckism immortal, and the integrative action of the nervous system supplies the reason.

This well-worn subject is not out of place here, where I am trying to show evidence of self-expression in terms of muscular modification arising from fresh activities of the brain.

New Muscles.

If it can be said without fear of question that "the differentiation of muscle and nerve is the morphological result of division of labour, whereby the unit of protoplasm, in which irritability and contractility are combined, has, on the one hand, become modified into muscle, which retains the property of contractility, and on the other into nerve, which retains that of irritability,"¹ and if Wolff's *Law of Bone Transformation* teaches that if a normal bone is used in a new way its structure and form will change to meet its new function, which Sir Charles Bell had more vaguely taught in 1834, it cannot well be denied that at certain turning-points in the history of animal organisms the sequence of changes which arise is neural change, muscular modification and finally change of bone, whether ungulates, carnivores, felidæ, gibbons or big anthropoids or man, be the *dramatis personæ*. The only question is whether selection or use and habit initiates the subtle and slow process.

Unstriped Muscles.

The simplest of the muscular acquirements of mammals is of course that great mass of little structures which constitutes the unstriped musculature. I must admit that here again I am engaged with what the professed biologist may call trifles, but these, like some others of a corresponding rank, have a provoking quality of persistence, and display, if one may personify them, an insistent desire to know whence they come and why they are here. Some of these, like the one before us, may be comprehended in the great chapter of the Evolution of the Indifferent of which they form a page. This world, at any rate in the moral sphere, would be an

¹ Macalister, *op. cit.*, p. 62.

intolerable house of bondage if there were not many *things that matter not* as well as *things that matter*, and there is reason to believe that in the process of the making of man and a vast number of forms below him there is a large field of structures, parts and organs, where things that matter not are to be found. One strange province of this realm is the colouration of animals in certain regions where no eye ever can see the colour or can take any heed of the markings, treated very fully many years ago by Mr. Beddard in *Animal Colouration*.

Unstripped muscle arises, as the striped variety does, from the mesoblastic muscle-plate and appears in nearly all organs, blood-vessels and skin, and as trade is said to follow the flag, so a development of new unstripped muscles must speedily be found in every new structure of the regions where unstripped muscle is found. The skin is the simplest, and less complicated by the presence of other structures than vessels and organs, where it also exists, but where it trespasses too much on the territory of selection for my immediate purpose. A small band of this muscle called an *arrector*, or *erector*, *pili* is attached to most, if not all, of the third of a million hairs which cover the skin of man, and is inserted into that side of each hair which forms an obtuse angle with the plane of the skin. This tiny structure is endowed with the quality of contracting in response to certain stimuli falling on the skin, so that it causes the hair to which it is attached to stand erect instead of sloping, and incidentally squeezes some of the secretion out of the sebaceous gland which lies in each angle. The human skin thus possesses about a third of a million minute muscular bands and shows no sign of parting with this old gift from a lower hairy stock, and whatever value, if any, their function be to their possessor they show a remarkable readiness to perform it efficiently. It makes their existence and persistence no clearer to call them vestigial, for one only thus throws the question of their origin much farther back. Undoubtedly they come from afar and were in full development in the earliest hair-clad mammals, so an ancestry reaching back to Monotremes or Marsupials is not to be lightly set aside. The raw material was undoubtedly formed in response to stimuli conveyed to the brain, and the earliest appearance of muscles which erected the hairs must have been wholly insignificant either upon the survival or comfort of the possessors.

A Remarkable Example.

The *arrectores pili* exhibit very little evidence of control or interference from the action of the brain, but there is one region

of one animal, like the Rosetta stone that set Champollion at work, where a very simple hieroglyph is recorded. I have been able to find no other in all the hairy mammals I have examined than that startling pattern which the back of the lion, shown in Fig. 37, sometimes displays. That well-formed patch of reversed hair of roughly triangular shape which is frequently found on the back of a lion has been described and, as I interpret this strange structure, it would seem clear that neural change in some examples of this species has led to so persistent contraction of the *arrectores pilorum* over a certain area of skin, and that these have permanently reversed the normal and primitive slope of the hair. I have never found it present in a lioness, and not in all cases of male lions. It marks its possessor with the brand of a fierce and especially savage character, and he is not able to screen it from the eye of the Zoologist as well as Milady did her brand of shame, until that fatal day when D'Artagnan disclosed it. This pattern on a lion's back is strangely reminiscent of the ridge of bristling hair we see on the corresponding region of a fierce dog's back when he is infuriated. In the latter it may be said to have selective value, as perhaps also is the bristling hair on the head of a gorilla when enraged, much in the same way as the Chinese warriors sought to alarm their enemies by terrifying grimaces, or those terrifying tones and expressions of face which the Tyrant man, really a coward, is said by such as Miss Wisk to exercise over the women of his circle. We may present all these to the Pan-Selectionist, but inasmuch as the short, bristling hairs on the back of a lion are on the one hand hidden by the mane from an animal in front, and on the other are so small as to be seen quite close if at all, the survival-value of the reversed pattern of hair in question is quite outside the province of selection. It is so manifestly under the control of cerebral action, that it may be compared, as an undesigned experiment, with that of man in placing harness upon a horse, as to the power of cerebral action in producing structure. Though, as far as I can learn, it stands alone, it is difficult to believe that such a thing as a unique example occurs in nature, but it is interesting and suggestive from the Lamarckian point of view, and even the opposing counsel must admit that it is among indifferent structures.

Facial Muscles of Expression.

This record in terms of hair of personal and ancestral emotions has, however, a link with certain more numerous and important striated muscles, such as the facial muscles of man and apes, modifications of the great platysma-sheet, and which are disposed

in two layers, a deep and a superficial. This covers like a hood at the third month the head and neck of the embryo, and later assumes on the face its specialised form of certain bands which operate round the eyes and mouth. As they are of the striated kind these muscles can be moved at will, but their main action is much more under the government of the mental processes of their possessor. As they are fundamentally the same in apes and man very little new muscular structure arises in man, and little more than shaping or refining takes place.

The facial muscles which operate round the orbit have less mental action represented in them than those of the mouth, though the action of the special elevator of the upper eyelid is conspicuous among the expressions of a vigorous person. Both apes and man have muscles on each side which raise or lower the angles of the mouth, draw the angles upwards and outwards, and raise the upper and depress the lower lip; and, though the muscle of the mouth which corresponds to the *orbicularis* of the eye is not a continuous structure, but formed of interrupted bundles of fibres, it is powerful in closing the lips and active in the expressions. There are also in man scattered oblique fibres in the substance of the lower lip, well-developed and closely-set in a sucking child, and these in the adult are scattered and less conspicuous.

There is thus a remarkable set of structures in the face of a higher primate which convey mental emotion. As they also belong to animals with a high degree of convolution of brain, though certain are found in lower mammals, their specialisation is only to be accounted for by the long-continued involuntary expression of mental states existing in the particular form of primate. Professor Keith says in the work before referred to: "Muscles supplied by the facial nerve are the physical basis into which many mental states are reflected, and in which they are realised. Through them mental conditions are manifested. It is found that the differentiation of this sheet into well-marked and separate muscles proceeds *pari passu* with the development of the brain. The more highly convoluted the brain of any primate the more highly specialised are its facial muscles,"¹ and he points out in a smaller work² that in the gibbon, and monkeys of the Old and New Worlds the facial system becomes simpler and at the same time more robust, and he pictures the facial muscles as the "servants of the brain."

¹ *Embryology.*

² *The Human Body.*

If an ape can express a good many of the coarser emotions of an animal by the action of its facial muscles, and through kindness and training exhibit some of the finer ones, there is a wide distance between this level of attainment and the multiplied moods and unnumbered varieties of expression which give to the human face its unique charm. If we can express pleasure, pain, anger, contempt, hatred, surprise, affection, sympathy, fear, hope, reflection, perplexity, gaiety, melancholy, cunning (and many another can be supplied) what a remarkable field of physiology in terms of anatomy we have in the facial muscles! There is a very obvious reason why none of these emotions have been fixed in an objective form in ape or man, as the patch of reversed hair is on the back of a lion, for moods and states of feeling in every individual man are subject to such endless variations that it would be impossible for them to stamp any individual face with a record of even one emotion which could be transmitted to descendants, to say nothing of the inconceivably great probability that heredity would at once swamp any initial modification.

Three Stages.

The stages then are but three—mental states, specialisation of small muscular bundles from an existing simple sheet of muscle, and disuse of the remaining portions, and in this small but highly significant field we see structures created independently of will as servants of the brain, and without any survival-value in their earliest stages. It is more than likely no monkey, ape, or early man whose face was covered with thick hair from his eyes downwards, ever saved his life or gained a better mate by reason of the subtle modification of a tiny muscle which was proceeding *pari passu* with the growing complexity of his convolutions and their manifested emotions. This is not to claim that a more modern man or woman would not find sexual selection of value by reason of his or her more pleasing or commanding facial expression. That the initiative of these alluring modifications was simple and Lamarekian cannot be gainsaid, whatever the fruit of the finished process may be to-day. We know in our own experience that many a handsome person with good features and little expression is often unsuccessful in the matrimonial market, when another with defective features and a fine, delicate, attractive expression takes the prize. So the early story of the formation of muscles of expression is seen to be a page in the evolution of the indifferent.

The Fly-shaker Muscle.

The panniculus carnosus, of which the facial muscles are part, is a great system of musculature found in various animal forms, and it furnishes a field for study of the evolution of the indifferent and the initial stages of the formation of a muscle. This is a servant of the brain in a more indirect manner than the facial muscles, but it, too, arises in obedience to the integrative action of the brain. The early specialisation of it need not be considered here. It may be considered unwarrantable to claim the great Fly-shaker muscle of Ungulates as an indifferent structure, but the arguments by which the Pan-Selectionist would annex it to his sceptre, as a triumph of the minute care of the organism by selection, rest only on the assumption that he knows how it has become an adaptation to the life of its possessors. This is now more than it used to be a matter of opinion since the publication of Professor Bateson's revolutionary *Materials*, and others beside he have reserved to themselves the liberty of doubting the accepted explanations by the tangled path of adaptation. The statement of Weismann, "Everything is adapted in animated nature" was necessary to his theory of germinal selection, but it admits of extensive and numerous exceptions in view of the fact that so much of adaptation is partial and imperfect. If he had said that *every organism* as a being is adapted he would have been nearer the truth, but that every tissue and part of an organism is adapted is demonstrably untrue. A large number of organisms, themselves apparently well adapted, flourish well enough and reproduce their kind in spite of faulty and rudimentary tissues and parts. If it were not so we should have seen little of progress except what come under the laws of genetics,—a distributional matter. Even the super-Geddes could not distribute what was not there, for he could not deal with raw materials and change them by a fairy wand into manufactured articles. In the great field of domesticated plants and animals man has to find not only some mutation or some dominant strain and breed it to his will, but to cultivate the domestic qualities of animals and employ cultural conditions for plants. There is doubt expressed as to the length of time or numbers of generations during which these cultural conditions can extend, but Professor Thistleton Dyer many years ago made the remarkable statement as to plants :—"While specific stability under constant conditions appears to be the rule in nature, it is widely different in cultivation. When a plant is brought under cultural conditions it maintains its type for some time unaltered, then gives way and becomes practically plastic. From my experience at Kew,

where I saw the process continually going on, I hazarded the generalisation that any species, annually reproduced from seed, could be broken down in five years. During that period specific stability, though menaced, tends to maintain itself. Darwin was well aware of this."¹

Most biologists from time to time betray the fact that their minds can only be relieved from an intolerable burden, in accounting for the numberless adaptations in organisms, by the view that many of them originate through factors of use and stimuli from environment, and at first are entirely indifferent as regards the survival or better mating of their possessors. To which the stern opponent replies, "What is there to show that in the existing scheme of things there is any provision made which will minister relief to the burden of your little mind?" To which, "answer came there none," except a subdued reflection that everything we see of living, striving nature around us has a most provoking way of speaking to us of daily, hourly and incessant action and reaction, stimulus and response, and that those who view the process thus do seem to bring some order into what would otherwise be chaos—and yet all the while someone is being grossly deceived! This "may be magnificent but it is not proof," some will say, and will ask if the older observers of the heavenly bodies were not wrong in their complete conviction that the sun went round the earth. This digression introduces the rôle of the fly-shaker. If I am told that this muscular sheet in a cow or horse to-day is a relic of raw material inherited from a remote ungulate stock little evolved, and that it contributes in hot weather in the time of flies to the comfort and better mental state of the cow or horse, that it shall be able to keep those enemies at bay, and that the muscle is kept well in order by two or three months' practice in each year I can understand in a measure its presence to-day. It has an efficient ally in the sweeping tail of a cow and that of a wild horse, and both of these weapons are further aided by the mobile ears of cow and horse, and the stretching movements of its head and neck. Thus the body of a cow, for example, is like a map with four territories delimited, that of the fly-shaker, the tail, the ears and the head and neck. Between these offensive weapons a cow is better defended against flies than a European in India by his punkah, or China was by its great wall, or Britain by the wall of *Vallum* of Hadrian or the wall of Severus, which with forts and garrisons was designed to protect it. Speaking in allegory the evolving brain of an early

¹ *Nature*, November 28th, 1907, p. 78.

ungulate occupies the position of an ancient Chinese Emperor or a Roman Proconsul in Britain in its provision against "barbarians," either Asiatic or Celtic. The resemblance goes further, for no experienced Roman General, whatever the Celestial minds in China may have thought, would fear that the loss of a sector of his wall would imperil the army of occupation in Britain or the fabric of the Roman Empire. But as, in the long run it contributes to one's welfare to be comfortable, and even the domestic ungulate is somewhat of a hedonist, a well-developed fly-shaker is maintained, the occasional use of which in winter and frequent use in summer and the active purposeful switching of tail, twitching of ears and jerking of head have their limited value. Here there is ample room for diverse opinion and the opponent will ask with some degree of force how we know that there is no more benefit to the cow from its fly-shaker than a mild degree of comfort, and may assert that the possession and use of it may have survival-value by its defence against deadly parasites. We do not know, nor does he, but it would seem that except for the tsetse fly in Africa the plague of flies does little to an ungulate beyond irritating its brain, and if he had no fly-shaker, he would still be able to reach a considerable distance with his tail, ears and head over the irritated regions. The question of survival indeed resolves itself into the vigour and energy of his integrating brain.

To this view of the function and origin of the panniculus carnosus the busy systematist and student of genetics may refuse to listen, and pass to the order of the day, but I submit that in stating a position it is useful to put forward a crude example in which the issue is plain, and which subsumes an immense number of smaller and more subtle cases, and in a region where the most hardy rebel will not dispute altogether the sway of *personal* selection. It is a question here of the manner in which, speaking in metaphor, the early ungulate first set about making his eolithic or palæolithic weapons and fashioned them into what we see to-day. "Forged by the incident of use" and habit meets the story of the fly-shaker far better than some mutation arising in far back ages or some dominant variation, or "useful variation within the germ." At any rate Lamarck finds the raw material to hand, and there are supplied adequate noci-cipient stimuli with response, in regions where these are most active under the dominating action of the brain.

Other Muscles.

In the skeletal muscles of the primates many muscles offer themselves for consideration as examples of inherited structures

arising under the stimuli of altered function, and only a few of these will be dealt with. It might appear sufficient to those who yield, perhaps too willingly, to authority, if I were here to try and prove my point by quoting the statements of one of the greatest anatomists of our time and country, and so pass on—but it is to be feared authority cannot carry one far in a dispute so important. Macalister says, however, “The anatomical arrangement of the muscular system is the physical exponent of habitual actions and those actions are the chief factors in moulding the bones and in regulating the position of the somato-pleural vessels and nerves”—and “the locomotory function and consequent utility of the trunk-muscles were lost when the early vertebrates became terrestrial. In higher vertebrates, and notably in man, the mobility of several regions of the vertebral column differs both in degree and kind: the outgrowing vertebrate processes show consequent variations, and the muscular system is varied accordingly.”¹ Also “as both origins and insertions (of muscles) are the creatures of habit, they are both equally variable with variation of function; but, as in higher animals the kind of work to be done is more constant than its degree, so, as a rule, insertions alter less than origins.”² Macalister, at any rate, held a very clear dynamical rather than static view of the making of the muscular system. But as the days of authority are in a certain sense gone for ever, and we live under the reign of experiment, research and questioning, every biologist, within certain limits, does what is right in his own eyes; there is no King in these days.

Skeletal muscles are structures in which, if ever, the factors of use and habit and disuse would be shown, because muscle is a tissue, with highly active metabolism, so that it has been called “an expensive tissue” for the animal to maintain.

Muscles of Primates.

This physiological fact agrees with the anatomical results of an extended study in the musculature of primates, especially of man, and Hartmann's book on Anthropoid Apes supplies abundant evidence of the variations of the muscles of these animals, which are not at all more striking than their differing modes of life would suggest. It would be wearisome to quote all these, but a single muscle may be given as an example of a special ape's muscle with variable distribution. It is called *latissimo-condyloideus* and starts from the insertion of the *latissimus dorsi* and passes along the inner

¹ *Op. cit.*, p. 71. (Italics not in original.)

² *Op. cit.*, p. 73.

aspect of the humerus for a variable distance. In the *baboon* and others it goes to be inserted into the inner inter-muscular septum and the internal condyle of the humerus, in the *orang* to the condyle, and in the *gibbon* to the centre of the shaft. As to origin it proceeds from the insertion of the *latissimus dorsi*, but in the *gorilla* from the coracoid process of the scapula and from two portions of the *pectoralis minor*, and is finally attached to the inter-muscular septum between the *brachialis anticus* and the *triceps*; in the *chimpanzee* it divides into an anterior and posterior portion, the former being attached to the inner condyle, the latter to the middle and inner head of the *triceps*; in the *orang* it divides similarly, but in one particular example it had an anterior thin portion attached by a slender tendon to the coracoid process of the scapula and a posterior portion arose from the *latissimus dorsi*; in the *white-handed gibbon* it arose from the function of tendons from the *latissimus dorsi* and *teres major* and was inserted into the fascia between the tendon of the *biceps* and the *brachialis anticus*.

Such a divergence as this within the strict limits of an anthropoid muscle, concerned in the various forms of climbing action of these apes, can only suggest an origin from a divergent set of functions and small details in their respective modes of climbing.

Hand and Foot of Man.

Both the hand and foot of man supply a small muscle for consideration in the present connection of habit with formation of new structure. If man be regarded as of simian origin there are not as many entirely new muscles in his equipment as would be expected from his departure from the habits of simian ancestors, though many muscles are found to be altered in size and shifted from the ancestral positions. But the human hand presents one suggestive example of a little muscle not found in any other animal, the special small extensor of the thumb, arising from the interosseous membrane between the radius and ulna, and from the radius, being segmented off from the *extensor of the metacarpal of the thumb*, and it accompanies this muscle and tendon to be inserted into the first phalanx of the thumb, and is peculiar to man. It can be easily seen at the radial border of the well-known "snuff-box" which is produced by it when it is fully extended. This is of course a muscle of small importance to the functions of the hand, and its appearance in man can only be supposed to be a subordinate detail easily derived from the *greater extensor* by reason of the more

delicate adjustment to complicated movements of the hand under the directing power of higher cerebral development.

Peroneus Tertius.

The foot of man possesses the small *peroneus tertius* which was referred to as one of the evertors of the foot concerned in the construction of his plantar arch. Macalister and Professor Keith both speak of it as peculiar to man, and the latter refers to it at some length,¹ the whole passage being worth quoting here. "Although the evolution of the human method of progression was attended by a profound alteration in the form and action of every muscle and bone with lower limbs, yet this great transformation was produced without the appearance of any really new element. One new muscle—the *peroneus tertius*—did appear, and the history of its evolution throws an interesting sidelight on the origin of new structures. It arises by the outer fibres of the common extensor muscles of the toes being separated. In all the anthropoids the feet are so articulated at the ankle-joints that the soles are directed towards each other, and only the outer edge of the foot comes to rest on the ground when the animal tries to stand. The feet have a tendency to assume a similar position in children at birth. The advantage of a muscle, such as the *peroneus tertius*, is apparent in the human foot, for it tends to raise the outer border of the foot, so that the sole is properly applied to the ground. If we examine the muscles which, rising from the front of the leg, cross the ankle-joint to end on the back of the foot on the toes of fifty men, we shall find every stage in the evolution of this muscle. In one man at least it will be undeveloped; in two or perhaps three it will be represented by a part of the tendon of the extensor muscle of the little toe, which in place of ending entirely on the toe sends a part to end on the metatarsal bone of the little toe. In only forty of the fifty men will the *peroneus tertius* be found quite isolated from the parent muscle—the *extensor communis digitorum*, and to have a distinct origin from the fibula in the leg, and a separate insertion to the base of the fifth metatarsal bone in the foot. In a series of fifty specimens every stage in the isolation of this new muscle will be seen. It has never been found in any anthropoid, and is more often absent or undeveloped in African than European races."

To this excellent account I have only to add one comment. It can hardly be an accident or without significance that this special

¹ *The Human Body*, p. 92.

human evertor of the foot concerned in the construction of the plantar arch is "often absent or undeveloped" in African races, which are well-known in some groups to have adapted themselves to a form of foot which shows no plantar arch, being normally flat-footed. In this small field of observation, a mere plot of lentils like that which Shammah defended of old, there is set forth a mimic battlefield, and it is not difficult to see that the forces at work can owe allegiance to one and one only of various commanders. The problem as to the origin of the *peroneus tertius* would no more attract the Mendelian than did the trousseau and approaching marriage of Caddie Jellyby attract the far-away gaze of her mother, fixed upon the world of Borria-boula-gha, and, for that matter, de Vries would hardly pay it more attention—to him it would be indifferent; whereas Weismann would have as much to say about it as about the little toe of man, which furnished for him and Herbert Spencer such fruitful material for debate many years ago. This muscle resembles the results of some of Michael Angelo's first attempts at sculpture, thrown aside perhaps in his place of work and from time to time taken up, rough-hewn again and again and finally shaped into a form far from perfect, but with the value and teaching of a failure for him who was some day to outshine all modern rivals. If the history of this muscle be not one of initiative in evolution through the factor of use and habit the Pan-Selectionist must do the best he can with an incalculable number of "trials and errors," and must suppose that, rather than allow this small territory to the neo-Lamarckian, a long series of man's ancestors have been making experiments for the benefit of man's walking power under the guidance of selection with an insignificant muscle whose only function is that of aiding in the eversion of the foot, and that in the rudimentary condition described by Professor Keith it had selective value. No one who was not committed to a dominating theory could hesitate for a moment which of the two alternative views of the origin of the *peroneus tertius* he would choose. Dr. Barclay Smith speaks in the paper referred to above of the *extensor brevis pollicis*, or *minor*, as a muscle of extremely late appearance, and as "peculiarly human," and says all the evidence points to its being a segmentation product of the *extensor ossis metacarpi pollicis*, its appearance being foreshadowed in the anthropoid by an extension of that muscle on to the proximal phalanx of the thumb.

It is not without interest to the thesis before us to read the rather bewildering story of the early life of a very insignificant muscle such as the small extensor of the thumb of man.

As illustrations of the moulding and pruning of perfected muscles it may be remembered that, as Macalister says, "portions of muscles may also become detached and degenerated so as to act as ligaments," and "the adult muscular system of man bears everywhere traces of earlier cleavings and subsequent fusions, partial disappearances and local outgrowths."¹ This passage recalls one in which Huxley says in watching certain phases of development you can almost see the hidden artist at work, and here the sculptor may be pictured in his chipping, trimming, rejecting and finally shaping, some creation of his brain ; and from a biological point of view a vision of the processes of use and disuse may be obtained. Professor Keith also speaks often of the migrations of muscular attachments in a way which agrees with the passage quoted from Macalister.

¹ *Op. cit.*, p. 73

CHAPTER XXIII.

INNERVATION OF THE HUMAN SKIN.

FOR at least seventy years the surface of the human skin has been the subject of so much physiological observation and experiment that Professor Sherrington considers the literature connected with it to be probably greater than in any other branch of physiology. Most of this study centres round the skin as a receptive field and problems of the nervous system. It is easy to see why this should be in the case of an organ so great as the skin, covering all the other structures and organs and exposed through ages of evolution to the vicissitudes of an inconceivable number of stimuli. And one outcome of this study is to show that, metaphorically speaking, the skin is a mosaic, and not the confused and blurred production of a child of four years old who has been given a sheet of paper and a paint-box. There is order in this field, and even without calling in final causes, plan and purpose. Beside the protective function exercised by the skin it plays a large part, through its nervous endowment, in the processes by which the brain is made aware of the surrounding phenomena, thus conveying intelligence to the centre of life only less important than that of the special senses. It is maintained here that the result of the various physical stimuli, of which pain, cold, warmth and touch are the chief, is that certain functions and structures of the skin have arisen in response to them.

This is, no doubt, to beg the question of origin, and if the balance of evidence be seen to be against this view the order of events would need to be stated differently. But the position is clear, whether correct or not, and if it be shown to be erroneous it will at least have good "lighthouse value."

Observed Facts.

Briefly stated the facts of the innervation of the skin are of two orders, anatomical and physiological; the former examined by the aid of the microscope, the latter by physiological experiments of a varied kind. The chief aspect in which these are viewed here is the mode of distribution of these two groups of fact, and it is held that this strongly suggests without proving it, the alleged mode of origin of both.

TABLE I.—*Distribution of Touch Corpuscles :—*

In the deep connective tissue of the dermis there are :—

In the thumb about 70.

„ „ index finger 105.

„ „ middle finger 60.

„ „ whole hand 500.

They are numerous over finger joints and front of elbow joint.

In all 530 about the joints of the upper extremity.

317 about those of the lower extremity.

TABLE II.—(From Schäfer's Text Book of Physiology) :—

Average of Meissner's corpuscles to each square millimetre, which is approximately one five hundredth part of a square inch :—

| | |
|--|----|
| Palmar surface of distal phalanx of index finger | 21 |
|--|----|

| | |
|--|---|
| Palmar surface of second phalanx of index finger | 8 |
|--|---|

| | |
|---|---|
| Palmar surface of first phalanx of index finger | 4 |
|---|---|

| | |
|---|---|
| Palmar surface of metacarpus of little finger | 2 |
|---|---|

| | |
|--|---|
| Plantar surface of distal phalanx of great toe | 7 |
|--|---|

| | |
|------------------------|---|
| Middle of sole of foot | 2 |
|------------------------|---|

| | |
|---|---|
| Flexor surface of forearm in each sq. mm. | 1 |
|---|---|

| | |
|--|--|
| Distal end of flexor surface of forearm in each sq. mm. :— | |
|--|--|

| | |
|------------------------------------|--|
| 1 to each 6 sq. mm. approximately. | |
|------------------------------------|--|

* Absent from the cornea, and conjunctiva of the upper eyelid and from the glans penis.

TABLE III.—*Distribution of Touch Spots :—*

These must be distinguished, of course, from the touch corpuscles of the preceding list and the subjective element in the study of them must be borne in mind.

If an area, as of the calf of the leg, be prepared, by cutting short the small hairs, and examined, it is found that there are about 15 touch spots in each square centimetre, which is about one-fifth of a square inch.

In another area so treated the hairs are counted and the following result is given :—

1. On the dorsal surface of the forearm 78 touch spots are found in an area containing 15 hairs.
2. On the flexor surface of the forearm 147 touch spots are found in an area containing 22 hairs.
3. On the scalp 66 touch spots are found in an area containing 38 hairs.

Schäfer says : " An area of the dorsum of the distal phalanx of a finger contains about seven times as many touch spots as an equal area between the shoulders. Regions poor in touch spots are the flexor surface of the upper arm, the upper third of the thigh, the leg above the inner malleolus, the neck, and in general the skin over subcutaneous surfaces of bone."¹

TABLE IV.—*Distribution of Cold and Warmth Sensations.*

The Scale includes twelve grades of sensation in cold, and eight in warmth sensations, and commences with the regions which yield the maximal intensity of sensation.

Cold Sensations.

1. Tips of fingers and toes, malleoli, ankle.
2. Other regions of digits, tip of nose, olecranon.
3. Chin, palm, gums, glabella (a small central area just above bridge of nose).
4. Occiput, patella, wrist.
5. Clavicle, neck, forehead, tongue.
6. Buttock, upper eyelid.
7. Lower eyelid, popliteal space, sole, cheek.
8. Inner aspect of thigh, arm above elbow.
9. Intercostal spaces along region of axillary line.
10. Areola of mamma.
11. Nipple, flank.
12. Certain areas of loins and abdomen.

Warmth Sensations.

Absent from lower gums, mucosa of cheek at second lower molar and cornea.

1. Tips of fingers and toes, cavity of mouth, conjunctiva, patella.
2. Remaining surfaces of digits, middle of forehead, olecranon.
3. Glabella, chin, clavicle.
4. Palm, buttock, popliteal space.
5. Neck.
6. Back.
7. Lower eyelid, cheek.
8. Nipple, loin.

TABLE V.—*Distribution of Cold and Warmth Spots.*

By stimulation of cold or warmth spots there is shown, not only the quality and quantity of the stimulus, but the locality. When punctiform stimuli are applied to pairs of

¹ Schäfer's *Text-Book of Physiology*.

cold spots and pairs of warmth spots marked "local sign" is found. This Goldscheider showed to be higher for cold than warmth spots.

| Cold Spots. | | Warmth Spots. |
|--------------------------------|---------|---------------|
| Palm | .8 mm. | Do. 2 mm. |
| Cheek, Chin and forehead .. | 0.8 mm. | Do. 5.0 mm. |
| Upper arm .. | 2 mm. | Do. 3 mm. |
| Back of hand, leg, thigh | 3 mm. | Do. 4 mm. |
| Forearm | 3 mm. | Do. 3 mm. |
| Back, chest, abdomen | 2 mm. | Do. 5 mm. |

Thus on the palm of the hand two pairs of cold spots .8 mm. apart are distinguished by this punctiform stimulation, whereas on this surface two pairs of warmth spots are only distinguished when they are 2 mm. apart on the cheek, chin or forehead and cold spots are distinguished when .8 mm. apart on the same surfaces warmth spots when 5 mm. apart.

TABLE VI.—Average lowest distances in millimetres on different areas of skin where two points are felt as two or minimal distances from which double sensation is obtained.

| Skin Region. | Adult Man. | Boy aged Twelve. |
|---|------------|------------------|
| Tip of tongue | 1.1 | 1.1 |
| Palmar surface of tip of finger (index) | 2.3 | 1.7 |
| Red surface of lip | 4.5 | 3.9 |
| Palmar surface of 2nd phalanx of finger | 4.5 | 3.9 |
| Dorsal surface of 3rd phalanx of finger | 6.8 | 4.5 |
| Side of tongue | 9.0 | 6.8 |
| Tongue 27 mm. from tip | 9.0 | 6.8 |
| Plantar surface of distal phalanx of great toe .. | 11.3 | 6.8 |
| Surface of palm of hand .. | 11.3 | 9.0 |
| Dorsal surface 2nd phalanx of finger | 11.3 | 9.0 |
| Forehead | 22.6 | 18.0 |
| Back of ankle | 22.6 | 20.3 |
| Back of hand | 31.6 | 22.6 |

| Skin Region. | Adult Man. | Boy aged Twelve. |
|---------------------------------------|------------|------------------|
| Forearm and leg .. | 40.6 | 36.1 |
| Dorsal surface of foot .. | 40.6 | 36.1 |
| Surface on outer border of sternum .. | 45.1 | 38.8 |
| Back of neck .. | 54.1 | 36.1 |
| Middle of back .. | 67.1 | 31.6 to 40.6 |
| Upper arm and thigh .. | 67.1 | 31.6 to 40.6 |

TABLE VII.—(*According to Weber's Law.*) Average differences in different regions of skin of sensation of pressure.

| | | |
|--|---|----------------------------------|
| Forehead | } | $\frac{1}{30}$ to $\frac{1}{40}$ |
| Lips | | |
| Dorsum of tongue | | |
| Cheeks | | |
| Temple | } | $\frac{1}{10}$ to $\frac{1}{20}$ |
| Finger nail | | |
| Dorsal surface of forearm, leg, and thigh | | |
| Dorsal surface of hand | | |
| Dorsal surface of 1st and 2nd phalanges of fingers | | |
| Palmar surface of finger | | |
| Palmar surface of hand | | |
| Flexor surface of forearm | | |
| Dorsum of foot | } | More than $\frac{1}{10}$ |
| Dorsal surface of toes | | |
| Plantar surface of toes | | |
| Sole of foot | | |
| Surface of leg and thigh | | |

Thus on the forehead differences of pressure are distinguished when they are increased by $\frac{1}{30}$, whereas on the dorsum of the foot they have to be increased by $\frac{1}{10}$ to be distinguished. This is carried out by impact of little balls of a light substances such as pith.

It may be remarked of these tabulated results that on the one hand they are the results of work extending over some seventy years and numerous observers, and on the other that, broadly looked at, *they all tell the same story* of stimuli in their incidence on the skin—those of pain, cold, warmth and touch. There is also one thread of origin running through all, and that is that the regions most exposed to the four stimuli show the highest development of specialised function and structure.

Some Aspects of the Nervous System.

It has been said with some truth that the telephone has struck a mortal blow at such serenity of life as the Juggernaut Car of modern progress has left us. But if it has done nothing else it has furnished the physiologist with a good illustration when he sets out to expound the functions and arrangement of the elements of the central nervous system and its peripheral expansion. In addition to this general light upon a great matter the vivid experience of many an Englishman during the recent years of war adds point to a subordinate phase of the general story of the telephone, for it represents my contention as to the origin or initiative of the sensorial areas of the mosaic under consideration. Modern persons may be divided into two classes, those who want and those who do not want the telephone, and the former may be sub-divided into A, those who can, and B those who cannot get it (or could not). A and B from the present point of view may be termed Receptors, though to call the B people by that name is to speak Hibernically. With this war-time experience in our minds, we may picture a vast period of time during which the stimuli of pain, cold, warmth and touch were hammering on the skin both before it began to lose its chief hairy covering, and after that process had left man still a hairy animal, but with much-diminished amount of his ancient heritage. These stimuli fell upon the skin very much as the class A, among telephone receptors, spent numerous fruitless stimuli on Postmasters-General, Ministers in Parliament and in "short" bitter letters to our bright little *Daily Pope*, and who yet found themselves not "connected up," as the saying goes. There is no knowing how long it was before they had enough effect on the delicate nerve fibrils struggling up into the epidermis and produced receptors or were "connected up" to the exchange or central nervous system. I am inclined to liken the pain stimuli to the short letters referred to, the cold and warmth stimuli to those addressed to the Postmasters-General and the touch stimuli to those which fell upon Ministers at question time.

Another comparison of the peripheral portion of the nervous system to common things has at times forced itself upon my mind when reflecting on the stimuli which are continually assailing the skin, as I have watched on the Needles' Downs a flock of sheep on a summer evening returning to their fold. As the sun begins to set they are scattered over the western end of the Downs, still cropping the short grass clothing those chalk and flint slopes which from immemorial time has alone flourished there. They wander singly or in small groups on such parts of the slope as the intrusive golfer

still allows, and gradually fall into larger groups which follow somewhat indefinite paths. As they move further and further towards home they are seen to follow one another in single file on some score or more of clearer paths, and finally converge into one well-beaten and broad path until they descend the northern slope and pass out by a single roadway into which a gate opens, and so reach the haven where they would be. Here one has a simple picture of the common stimuli of the skin, at first indefinite and ineffectual, by their cumulative action producing an individual receptor and its nerve connection with the central system.

Professor Leonard Hill¹ also gives a view of the general action of the nervous system and compares it to control of the police force. He supposes a murder to have been committed in a village, and that the local policeman telegraphs to the local town ordering the roads to be searched. The policeman is the tactile sense-organ, the telegraph wire is the sensory nerve, the telegraph office in the local town is the spinal cord, from this office a message is sent to the town police-station by another wire and the police are set in motion. The police are the muscles, the wire that sets them in motion in the motor nerve. The message is also sent to neighbouring towns and to London, that is to say, other local offices (parts of the spinal cord) and the head office (the brain) are informed of the crime or sensory impulse. The central office in London directs the operations controlling the local police office. The whole order of events need not be here described because it goes beyond my immediate purpose, but it is enough to say that attached to the head office are the cleverest detectives (higher sense-organs) and in these are kept records of past crimes, lines of action of the police, and success or non-success of their investigations.

Following on this picture he speaks of the way in which conscious actions become automatic and makes a statement to the effect that "*There is evidence to show that the axons (or processes of the nerve-cells which extend unbroken from nerve-cell to its termination) become covered with a medullated coat as each new tract is formed. Thus the structure, like the habit, becomes fixed*"—and—"*It would appear as if, by repeated experiences, tracts and pathways must be beaten through the nervous system*"¹ (Italics not in original).

Beside this I place a statement from Professor Graham Kerr as to his view of the development of peripheral nerve-trunks. He is reviewing the "outgrowth" theory of His, the "chain cell" theory of Balfour, and the "Primitive Continuity" theory of

¹ *Manual of Human Physiology*. Leonard Hill, p. 369.

² *Op. cit.*, p. 371.

Hensen, and expresses himself as follows : "*It is suggested that the development of the actual nerve fibril is simply the coming into view of a pathway produced by the repeated passage of nerve impulses over a given route.*"¹ (Italics not in original.)

A passage from Professor McDougall's *Physiological Psychology* may also be referred to at more length than it was in Chapter III., page 25. Speaking of the automatization of voluntarily acquired actions which have been explained by the view that purely reflex actions carried out by mechanisms of the spinal level were also originally acquired by our original ancestors as voluntary actions, he says, "This view is usually associated with the name of Wundt, who has forcibly advocated it. It implies, of course, the assumption that acquired characters are in some degree transmitted from one generation to another, a proposition which most biologists at the present time are inclined to deny because they cannot conceive how such transmissions can be effected. Nevertheless, the rejection of this view leaves us with insuperable difficulties when we attempt to account for the evolution of the nervous system, and there are no established facts with which it is incompatible. If, therefore, we accept this view we shall regard the congenital neural dispositions, both those that determine pure reflexes and those that determine instinctive actions, as having been acquired and consolidated under the guidance of individual experience, with the co-operation, to a degree which we cannot determine, of natural selection."²

These three statements from a physiologist, a zoologist, and a psychologist, all of great eminence, though they differ in particular problems studied, tell very strongly in favour of the position here put forward as to initiative in the production of specialised innervation of the skin.

Origin of Cold, Warm, Pain and Touch Spots.

The hair-clad skin of primitive man provided ample raw material for the eventual differentiation of both end-organs and sensorial areas which is found to-day. Not only did he possess what is called Common Sensation in his skin but in the individual hairs lay a delicate tactile structure, which, though probably inferior in delicacy, serves a similar purpose to that of the vibrissæ on the muzzle of Felidæ. Each hair, being deeply inserted into the skin and supplied with fine nerve fibrils, when it is bent, acts as a lever communicating an impulse to an afferent nerve trunk.

¹ *Text Book of Embryology*. Vertebrata with the exception of Mammalia. Vol. II., 1919, p. 106.

² *Physiological Psychology*. W. McDougall, p. 156 (1911).

In an animal covered with thick hair the sensory impulse conveyed might be exceedingly delicate, but, from the nature of the case, of much more limited range than in one like man in whom the hair is so greatly diminished in length and thickness.

It would be fruitless to speculate as to which of these four forms of stimuli was the earliest to become effective in developing man.

Cold and Pain.

Two of them, cold and pain, may be termed *nocuous*; one, that of touch, *useful*, and one, that of warmth, *indifferent*. If it be true, as Professor Scott Elliott states,¹ that man's earliest home had a climate which "lies between the regular tropical, with wet, steaming, impassable jungles, and the colder temperate zone, so affording chance of acclimatisation in both directions," the stimuli of cold would even then not be wanting, however much they increased in severity when he passed through glacial periods; but wherever, whenever, and at whatever time he first became man he had to tread the Via Dolorosa in the course of his hard and eventful life, and must have been well accustomed in all regions of his skin to the stimuli of pain, working, as he did, for his living, and fighting for it and his mate, with varied and powerful enemies. Though it is correct to call both these fundamental stimuli "nocuous," this is all a matter of degree, and both the stimulus of moderate cold, raising blood-pressure and activating metabolism, and that of minor pains, would do little else than good in his education for the higher terrestrial life to which he had descended. If he was to learn effectually to take care of himself the discipline of both moderate cold and pain would be as valuable to him then as in its measure it is to his descendant to-day. The triumphs of medicine and surgery could never have appeared if it were not for the beneficent warning voice of pain that so generally accompanies disease.

Through long ages of exposure to the stimuli of cold and pain came response in the form of cold and pain spots, after minute struggles between the static conservative tissues of the skin and the dynamic force of repeated assaults upon them. In due time then receptors appeared and each became connected with the central organs, by which means better adapted motor reactions against "nocuous" cold and pain became possible. In 1900 Professor Sherrington summed up the evidence in Schafer's work on Physiology against the existence "of separate afferent fibres with their specific

¹ *Prehistoric Man and His Story*, p. 92.

end-organs entrusted specifically with carrying painful impressions to a pain centre," but Professor Starling in his later work on Human Physiology speaks of "a distinct sense of pain," probably subserved by a distinct set of nerve fibres, but for the present purpose it is not necessary that agreement on such a problem should be reached, for it is alone with pain *spots* that we are concerned. He also points out that on the one hand the cornea is sensitive to only one of the four stimuli in question, that is, pain, and on the other that the surface of the glans penis is sensitive to cold and pain, but tactile sensation and warmth sensations are almost entirely absent.

Touch.—This form of stimulus and its response can only be reckoned as useful to the organism, except that it may be, and often must be indifferent. The great number of the touch spots can be understood when it is declared by Professor Sherrington that almost invariably there are one or more touch spots close to the emergence of each hair,¹ and that they are very numerous also on the palmar and plantar surfaces of the hand and foot. Of the four forms of cutaneous stimuli those of touch are the only kind that have so far been proved to have specialised corpuscles, the other three having developed the physiological equivalent of cold, pain and warmth *spots*.

Warmth spots are decidedly the least numerous of the four, those of pain being, as stated by Professor Sherrington, the most numerous. It is obvious that unless thermal stimuli become somewhat excessive they hardly can be described as "stimuli," being more or less neutral in their action on a warm-blooded animal. This cannot be entirely so, because it has been shown quite conclusively that warmth spots *do* exist, though much less numerous than others. There is a significant fact as to thermal reaction and that is that there are no pure *heat spots* like those of cold, for the stimuli of about 49° C are so associated with those of pain that warmth spots alone are distinguished, and among primitive man no stimuli of heat could impinge on his skin, until he had learned the use of fire, more powerful than those of solar heat.

Such stimuli of heat as the rays of the sun would occasionally discharge on the skin would resolve themselves into the general stimulus of pain, and in this direction a far shorter initiation occurred than with any of the four normal cutaneous stimuli. The fact, at any rate, of there being no *heat spots* is to be noted.

It remains now, having quoted three writers eminent in physiology, psychology and zoology in support of the modest

¹ Schafer, p. 922.

thesis here put forward for me to appeal to the authority of the facts contained in the tables for such evidence as they can give, and to give a summary of this.

Summary.

1. Table I. shows that the structures known as touch corpuscles are distributed on those parts of the skin where the stimuli of touch fall most and in proportion to the degree in which those parts are employed in tactile discrimination ; thus, most of all on the index finger (with the exception of the tip of the tongue) next on the thumb and less on the middle finger. There are 530 of these corpuscles to the upper and 317 to the lower extremity.

2. Table II. bears out the same conclusion, the average number of corpuscles to a square millimetre being twenty-one on the terminal, eight on the second and four on the first phalanges of the index finger, whereas on the foot there are seven on the great toe much exposed to stimuli and only two on the middle of the sole of the foot, which is little exposed. The absence of them from the cornea and conjunctiva, protected by quick and powerful reflexes from such stimuli, and from the (normally) covered glans penis is in accordance with the other results.

3. Table III. dealing with touch spots, shows that these are nearly twice as numerous on the flexor as the dorsal surface of the forearm ; and nearly five times as numerous as on the scalp, where tactile stimuli are few, and that the distal phalanx of a finger contains about seven times as many as an area between the shoulders. The regions poor in touch spots are shown to be those where relatively few tactile stimuli can fall.

4. Table IV. gives cold and warmth sensations graded according to the delicacy with which they are perceived in many regions of the skin. The cold sensations are best distinguished on the parts normally most exposed to cold, as the tips of fingers, malleoli, tip of nose, chin, patella, wrist, and least on the protected areas, inner side of thigh, flank, loins and abdomen. The warmth sensations are best distinguished on the regions on which the stimuli of warmth has most frequently fallen, tips of fingers and toes, cavity of mouth, palm of hand, less so on the neck and loin. And the striking fact is noted that warmth sensations are not felt in the lower gums, the inside of the cheek at a certain level and the cornea, which again is protected from these stimuli by its efficient reflex, whereas to the gums and inside of the cheek most warmth stimuli have not been "stimuli" at all.

5. Table V. also gives results of the mode of distribution of cold and warmth spots, examined with punctiform stimuli. The "local sign" for cold is higher than that for warmth spots, and two of these are distinguished as double when only 0.8 millimetres apart on the palm, cheek, chin and forehead, whereas on the upper arm, back and thigh, they are only distinguished as double when separated by two millimetres, and this distance is the minimum at which warmth spots are distinguished as two, that is 2 mm. on the palm, and five on cheek, chin, forehead and back. This tells the same story as Table IV., of past stimuli of cold and warmth.

6. Table VI. deals more elaborately than the others with double sensation in different areas of the skin, the tip of the tongue being the most accurate in this respect of all examined, and the tip of the index finger next, which is to the great toe as 2.3 to 11.3, the palmar surface of a finger half as accurate again as the dorsal surface, the palm of the hand twice as accurate as the surfaces of the forehead and back of ankle, nearly four times as much so as the dorsum of the foot and six times as the skin of the middle of the back.

There is here a very close relation between the amount of exposure of these various regions to tactile stimuli and their present equipment of ability to discriminate between two small objects.

7. Table VII. deals with the sensation of pressure in certain groups of areas, and shows that change of pressure is perceived about three or four times as accurately on the forehead, lips and tongue, as on the finger nail, back of forearm, hand, or fingers, and more than three or four times on the back of the foot, and sole, and surface of leg and thigh. In this group of observations also the rule is followed that the greater and more frequent in man's ancestral past have been the exposure of his skin to variations of pressure, the greater is his present power of accurate discrimination of them.

There are some scattered facts mentioned by Professor Sherrington which are in keeping with the line here taken, that the formation of receptors in the skin have their origin in accumulated stimuli. He refers to the vain endeavours of Goltz to evoke the reflex croak of the female frog by applying electrical stimuli to the skin, whereas non-nocuous mechanical stimuli were the only stimuli that proved effective.

He never was able to elicit the "extensor thrust" in the "spinal dog" by any form of *electrical* stimulation, but only by a particular kind of mechanical stimulus. This peculiarity was also found in the pinna reflex of the cat.

As to the scratch reflex in the dog it was only when it was *easily elicitable* that it could be evoked by electrical stimulation as well as mechanical, and when it was not easily elicitable electrical stimuli failed altogether while mechanical stimuli still evoked it.

He describes the receptor as a mechanism "*attuned* to respond specially to a certain one or ones of the agencies that act as stimuli to the body," and points to the fact that *electrical* stimuli are not of common occurrence in nature and no chance for adaptation to evolve in the organism receptors appropriate for such stimuli has been afforded. Such negative facts are at the least suggestive in considering the question of the mode of origin of receptors and end-organs, electrical stimuli being rare in nature.

The subject of the innervation of the skin and its receptors has been treated here in a great measure by the aid of imagination, with some evidence, and a good deal of reconstruction has been attempted, but perhaps this will be pardoned by those who are prepared to carry out a corresponding process with such as *Pithecanthropus*, *Eoanthropus* and *Saurian* monsters from somewhat scanty osseous remains. Any biological theory of the origin of these receptors than the one here put forward is faced with some formidable difficulties, which are probably insurmountable.

CHAPTER XXIV.

THE BUILDING OF REFLEX ARCS.

ASSUMING the foregoing origin of the innervation of the skin, I submit that between this rudimentary process and the building of sensori-motor arcs in the spinal cord and brain there is a field, almost unlimited, for initiative in the construction of new forms of animal life. The former is nothing without the latter. To leave it without proceeding further is to leave it "in the air" as military writers say. The formation of Receptors, then, both in the skin field and in the higher sense-organs, leads of necessity to the formation, multiplication and co-ordination of reflex arcs. As in an imperfectly organised telephone service after many a repeated stimuli or "rings" the messages begin to reach their destinations, and as by practice the operators better and better learn their business, so the impulses passing through receptors and nerve-fibrils become organized into more or less efficient systems of arcs, and response is secured to them by some effector of gland or muscle. It is not true of man alone that practice makes perfect.

A certain feature of higher animals which distinguishes them from lower must be remembered, and that is that among them the individual becomes increasingly important. Speaking generally, the latter are born and die in large groups, and their lives resemble those of their group more closely than in the former. The struggle of the individual is vividly pictured by Professor Woods Jones in his description of the baby of the perfected arboreal animals. He shows how they and the roaming Ungulates and Pelagic Cetacea cannot indulge in large families, and that it is only those forms which have a safe retreat for their young which can avoid reduction of the size of their families, and how the higher apes still more resemble in these respects mankind, as we know it. For the proper study of the "synthesis of the individual" organism this essential fact must be kept in mind.

Some Illustrations.

It will be expected of course that for the claim here advanced on behalf of the predominant influence of the nervous system in the initiative of the evolutionary process some experimental or other

evidence should be produced. Before entering upon this, I think some analogous facts from the story of man, in accordance with the principle laid down in the first chapter should be stated, so as to illustrate the line of thought. These will be in the nature of analogies, and whether or not the accepted accounts of the chosen examples agree precisely with the last word of the critics is immaterial, for if not they will equally well serve the purpose of illustration.

Abraham.

When from his Mesopotamian home an opulent and successful farmer decided for reasons sufficient to himself that he would leave his present prosperity for a promised land, and went out not knowing whither he went, it is manifest that the construction and organization of Abraham's cerebral cortex was the motive power which led to this step so fraught with change to himself, his descendants, and the world. By his choice he showed the inherited structure of his brain, its nature, and perhaps its nurture, to be different from those of his family and tribe. Implicit in this venture was the introduction of a new group of people into a new environment, and their reaction to it through many generations is written before our eyes to-day in indelible characters. It was neither stature, muscular development, colour of hair, skin or eyes, properties of digestive or circulatory organs, keenness of sight, hearing, taste, smell, or touch which led to this result even though without a high degree of efficiency of these he could never have "arrived" as he did.

Mohammed.

The conjunction of environment with a certain organized complexity of grey matter was hardly ever more important to the world than that of Mohammed. The powerful frame, abundant black hair, wonderful dark eyes, and great imposing head may well have attracted the rich widow who "made his fortune" by marrying him, and they stood him in good stead in his later adventurous career. But nothing short of a unique arrangement of his reflex-arcs, chiefly in the association-areas of his brain, could have opened up to him the world of Asia and Europe.

Columbus.

Who can doubt that it was ultimately to the inherited structure of the convolutions of his brain that Columbus owed his great achievement in opening up a New World; or that to the reactionary and intense "character" of Philip's brain the persecutions in the Netherlands were due; and on the other hand that to the brain

of William of Orange with its liberal and enlightened "character" the Seven Provinces that resisted Philip owed their freedom; the results in the two cases being the decay of Spain from that time forward, and the final success in the struggle for religious liberty. In such a view of historical facts it is not necessary either to follow Carlyle in his extreme claims for the influence of great men and heroes, nor to look upon the hero as an epiphenomenon. It is certain that eventually some other great man would have arisen to do what the great Genoese did, if he had not done it, and as it is claimed that Amerigo di Vespucci did, and it is certain that Philip was only the last of the Hapsburg sovereigns who determined the fall of Spain, and that Huss, Jerome, Wycliffe and Luther in their days initiated the struggle for religious liberty which Holland brought to success. But the facts referred to can hardly be disputed, and the men and their "characters" did certainly determine permanent changes in the world.

Napoleon.

Among individual men of modern times none strikes the imagination as does Napoleon. Without ignoring the tremendous outburst of the soul of down-trodden France at the Revolution, it cannot be denied that the "character" or grey matter of brain of the man of whom it is said "nothing where he had passed was as it had been before," was the dominant and natural fact that changed the face of Europe. What physical quality had Napoleon, except those of his grey cells, which could have led him to such results on the environment into which he was cast?

Migrations.

Similar results in nations and tribes can easily be supplied from the great migrations of the past. The wider movements are but due to comparatively small aggregates of adventurous men, in other words to the aggregation of many similar central nervous systems. The great Western and Southern adventures of the Scythian Tribes had many contributing causes on which the historian has much to say, and they were physically highly efficient for their new career, but, reduced to the simplest elements, it was neither their great stature, strong muscles, flaxen hair, nor blue eyes, but the cerebral constitution of a comparatively small group of them which brought part of the nation to the promised land, and left another and large part in their homes beyond and along the Danube. The subsequent story of the latter may well be compared with the invaders of Gaul and Italy in connection with initiative in evolution.

The successive invasion of Britain by Low German tribes in the fifth century, and the Scandinavian hordes of Swedes, Danes, Norwegians, Letts and Finns in the eighth and ninth teach the same lesson. The later condition and development of the Northmen in France, Italy, Spain, Sicily and Britain have only to be compared for a moment with that of their races who remained in Norway, Sweden and Denmark and their descendants, to bring clearly before one's mind the profound influence exerted by the cerebral constitution of the original Viking hosts on their career in their new environments, and, indeed, on the environments themselves; as in intermarriage with their conquered foes.

These examples have been chosen for the reason that one feature is common to them all, the introduction of an individual or group into new environments by reason of the constitution of their brains, irrespective of the contributing factors. If these be sound analogies they bear closely on the matter of initiative in the evolution of new forms of life. The men in question came to their task, in their day, with a certain equipment of brain derived from many ancestors and much nurture. Unconscious arbiters of their fate and that of multitudes who should follow them, they initiated a course of physical and cerebral evolution of which we can see much revealed before our eyes. The motive power of their conduct bears a relation to their physical forms that the engines of a motor-car do to its varied forms of body. The latter are modified indefinitely to suit convenience, comfort and grace, but fundamentally they exist and are energised by the former, just as structure is modified for the performance of function.

This fact is occasionally brought vividly to the mind of an observer when he first passes a Rolls-Royce car in all its glory and magnificence, and then a rough squalid kind of trolley in which the engine-parts of a similar future Rolls-Royce are out for trial. In principle it is not a long step from these illustrations to the diverse environments of animals in which their lot is cast, and their reaction to them as to behaviour and structural change.

Some Changes in Habits of Man.

There are two current views as to the present erect posture of man, one which traces it to the adoption of a new posture by a pronograde four-footed ancestor, and the other that man's ancestors were "never typically pronograde with four supporting limbs," but derived from an arboreal stock in which the forelimbs were mobile rather than stable. Whenever or wherever man became orthograde he opened up for himself and his descendants immense

regions of structural and functional change and became increasingly dominant over his environment. Changes in muscles, joints, bones, bursæ, lungs, heart, and vessels occurred through his employing in new modes the muscles, joints, bones, bursæ, lungs, heart and vessels he already possessed, and the resemblance between these structures of man and the great apes has given to the latter the name of anthropoid, and this similarity of structures in the highest Primates has done much to support in the past that Simian origin of man which is at present questioned. The behaviour of the apes and early man were sufficiently alike to lead either to a parallel or genetic similarity. This point is, perhaps, irrelevant in considering the great field for initiative in the formation of new physical characters, and chief among these new reflex-arcs which have built up the marvellous organ of man's glory and greatness ; but no one can dispute the elementary fact that the ancestor of man who adopted terrestrial bipedal locomotion and became orthograde, owed it to his growing brain and the higher integration of his organs for that function. But besides the new posture he had adopted he learned to talk articulately, to make tools, and to use stereoscopic vision. None of these could have been started on the upward way without a long process of trial and error in the course of his total experience and practice of his powers. The results that followed from these three properties of his are inconceivably great, and it is unnecessary to enlarge on such a theme or to add to the number of examples.

Leaving, then, the immediate ancestor to work out his own destiny in his new terrestrial home, we must as before proceed backward in the history of animal life in the line of Primate ancestry.

Primate Ancestry.

It is generally agreed to trace the Primates back to an active pioneer animal form which took to the trees, and which arose out of the widely-spread Insectivores. This derivation will probably satisfy any reasonable genealogist. But, if we may use a parallel in human families, this active animal was as different from its congeners as Napoleon was from his four brothers who played a part in European history, and it is not necessary to say more as to the significance of this fact than that the relative importance of "chassis" and "body" is again a useful analogy. But we need to ask what those congeners did if we are to succeed in understanding the Napoleon-like course of him who became our Primate ancestor. From the original widely-spread and plastic raw material of the Insectivores allied forms took different lines, and their stories are

written at great length in one small and the three other great orders of Bats, Carnivores, Ungulates, and Rodents. As it has been pointed out, Carnivores took to attacking larger prey, including their less fortunate relatives, and stepped into the arena as carnivorous animals; the Ungulates-to-be became herbivorous and developed into two great groups of hoofed animals, relying mainly on flight for safety; Rodents took to burrows for defence, ceased to trouble much about attack, and became gnawing animals; Bats adopted an aerial life—a poor form of it indeed like that of the aeroplane—and acquired a degraded fore-limb. Before leaving these great orders of animals, whom I do not desire to compare unfavourably with poor Louis, Jerome, Joseph or Lucien Bonaparte, it is convenient here to refer to a fact which comes to light immediately one looks into such a piece of classification as this of the orders arising out of the loins of the early Insectivores, and that is the functional conception underlying it. Doubtless pure functional “characters” could never supply a whole system of classification in the light of the modern doctrine of descent with modification, and of zoological affinities. This is shown in a change from division of six orders of Birds—Running, Swimming, Wading, Climbing, Predatory and Perching Birds, to that of a few old-fashioned Ratite Birds, and all the rest, one which seems the best that can be offered at present.

Insects, Mollusca, Birds.

The grouping of animals by structural characters, and by affinities which are assumed, though based on almost undeniable evidence, whether into species, families, classes, phyla or sub-phyla, has its apotheosis in Mollusca and Insects. As to the second of these immense groups it has always seemed strange that their colourings and structural characters should have received such intensive study from Weismann to the exclusion of Mollusca, when he set out to prove his stupendous negative, and still more that of Vertebrates, among which his chief difficulty and desired triumph would seem to have lain. Mollusca though invertebrate are held by many to be in the line of ancestry of the highest forms of life, and at any rate insects are not. They are most fruitful fields indeed in which Nature has been able to show what she could do by her stern selective powers, but, from the point of view of descent with modification, may be fairly compared to a review of an army in time of peace, or the Kriegspiel of a German military staff. He who concerns himself with the fundamental difficulties of the problems at issue in evolution must make his notes of what experts tell him

of such groups as those of Insects, Mollusca and Birds, and pass on to the higher forms in which on the one hand function becomes the predominant partner, and on the other individual experience becomes more and more important. He feels indeed at liberty to wish the entomologist and ornithologist all success, and to leave him at peace, in his siding, to pursue his delightful and interminable studies far from the dust and din of controversy.

Insectivores.

The critical territory of vertebrate, and still more of Mammalian forms, in which the genealogist pictures the five main groups of Insectivores, looking about them, if one may so speak, in the world around and pondering which of many paths they shall pursue, resembles certain centres that may be seen in towns where three, four, five, or seven different roads are open to the traveller, each with its incalculable effects on his ultimate career. If one may change here the metaphor it may be said that the Insectivores are the watershed of the Five Rivers of higher life. However much the wayfaring insect-feeders have diverged from this broad centre in structure, and however much the laws of genetics have widened this divergence, the facts of function stare one in the face when such descriptions of three of the four orders outside the Primate stock are pondered—Flesh-feeders, Herbivorous animals, Burrowers and Gnawers. These time-honoured names appealed strongly to older zoologists, and in them is implicit a large body of evidence for initiative in their evolution by pioneering work on the part of their ancestors. Though in these days Prototheria include Monotremes, One-vent animals, Metatheria, Marsupials or pouched animals, and Eutheria Insect-feeders, and though Mammals derive their indispensable name from the function by which they feed their young, the most severe of systematists cannot clear his mind from the old leaven of function in all these terms. They imply momentous potentialities prior to new structures, and the modern fails to ban entirely such functional names. I believe there is here no juggling with names and words on my part, but a stone in the foundation of the unambitious building which I am seeking to rear. It is ultimately connected with a directive power as well as the formation of sensori-motor arcs in the central nervous system.

Is it possible or probable that the factors which led some group to the water alone, some to a life in water and on land at different parts of their lives, some to a crawling life on land and partly in water, some to the air and trees, some to nocturnal, some to hibernating, some to burrowing life, some to a diet of flesh, some to one of

plants, some to the trees alone, some to the trees and land, some to the land by night and trees by day, and some for ever and wholly to the land—is it probable that any process of selection of suited structures with countless ages of trial and error, could have determined these changes of habit and habitat? At least one may claim that the balance of probabilities is heavily against that view, and that the forging of reflex-arcs, with all it means to the career of an individual, affords a more intelligible hypothesis, and that this is strongly supported by modern discoveries and doctrines arising from the work of physiologists, as will appear later.

The Place of the Nervous System in Evolution.

The constitution of the nervous system is conditioned by conduction, its fundamental and primary function. Its processes consist in the transmission of impulses from receptive fields to effective reactions through devious paths in a region which, even to-day, is a jungle, with many further secrets for physiology to reveal. From this point of view the nervous system may be looked at as a clearing-house and storehouse of impulses *on their way in, on their way through, and on their way out*. If so, the making of new reflex-arcs is a process which has gone on simultaneously with the formation of receptors in the skin, the higher sense-organs and such deep structures as muscles, and that of effectors of infinite variety—and these are called conveniently adaptations. When we hear from Professor Sherrington that the afferent fibres with their private paths which enter the spinal cord outnumber three times those which leave it, and that those of the cranial nerves should be added, so that the afferent fibres may be reckoned as five times more numerous than the efferent, we get a vivid idea of the fundamental importance of the formation and compounding of reflex-arcs into systems. Without that the most sensitive receptors and the widest range of structures and organs, small and great, would be as nothing and things of naught.

A neurone is the anatomical, as the reflex-arc is the functional unit of a central nervous system. Just as it is profitless to consider apart the engines and body of a motor car, as working machine, so is it to picture neurones and reflex-arcs separately in the living nervous system except for the purpose of an ideal construction. In common with the organs and structures of higher animals they have to pass, as historical structures, through the stages of initiation, repetition of rudimentary function, and selection by trial and error, till the “canalizing force of habit” issues in rudimentary and increasingly efficient effectors. It is in this final stage where the

triumphs of selection have been won, and where their undeniable value and interest has led some exponents of the distributional laws of genetics to disregard, or accept as data, the early and formative stages. Theirs is a mental state which resembles that of Darwin, who, for once in a moment of haste, declared the question of the origin of life to be rubbish.

In the foregoing consideration of the formation of receptors of the skin it was assumed that certain common stimuli of the environment hammer out for themselves paths in the nerve-fibrils of the skin and by ceaseless repetition lay down not only the receptor, which may be called the *terminus a quo*, but also the afferent fibres which ultimately find their way into the grey matter of the cord and brain. That this is the initial stage of the construction of the higher nervous system can hardly be denied. But it carries the problem of the synthesis of the organism but a little way unless it be coincident with the construction of new reflex-arcs and their co-ordination into systems. Till this stage be reached in a rudimentary form the most cunning and exact adaptations and structures, or, as they may be broadly called effectors, will not advance the efficiency of the organism in the smallest degree. If the receptor be the *terminus a quo* the effector is the *terminus ad quem*. This is so obvious that it may be waved aside as a truism not worth the notice of a zoologist concerned with the major problems of biology. It may seem to challenge in a highly speculative region and manner the labours of the biometrician and Mendelian, but, if fairly met it no more encroaches on their territory than do the labours of the engineers who invented the first and crudest chassis of a motor car upon the elaborate and brilliant ingenuity, taste and skill of the coachbuilders who turn out the "body" of a sumptuous Rolls-Royce of 1920. But the latter would never have "arrived" if the former had not made his slow and arduous trials and errors and final success. So here, as in many other subjects, a truism has its use. If the biometrician and Mendelian will only abstain from erecting notice-boards to proclaim "No thoroughfare here," we shall not be put down as trespassers or poachers on their ground and may range at large in certain fields of speculation.

Some Neural Phenomena.

Among numerous phenomena of nervous reactions discovered by the research of physiologists certain have a close bearing on the formation of receptors, afferent fibres and reflex-arcs, especially those of Delay, Summation, Fatigue, Block or Resistance, Localization, Facilitation and Inhibition.

Facilitation.

But of all these important reactions in nervous tissues none bears so closely on the problem of the formation of reflex-arcs as that of Facilitation. This is equivalent to the Law of Neural Habit of the physiological psychologist, and is bound up with the highly important Law of Forward Direction, which Professor Starling says might as well be spoken of as the Irreciprocal conduction of nerve-arcs. The Law of Forward Direction of sensori-motor arcs is too well known to need here any description. But when this law is taken into account the phenomenon of Facilitation is seen to throw a strong light upon the earliest and rudimentary formation of specialized nerve-fibres, reflex-arcs and Final Common Paths leading to the effector glands or muscles. Facilitation is described shortly by Professor Starling as follows. If the passage of a nervous impulse across a synapse or series of synapses in the central nervous system be too often repeated, fatigue is produced, and there is an increase of the block at each synapse. If, however the stimulus be not excessive and the impulse not too frequently evoked, the effect of a passage of an impulse once is to diminish the resistance, so that a second application of the stimulus provokes the reaction more easily, and he adds that the result of summation of stimuli is in fact in the direction of removal of block. When an impulse has passed once through a certain set of neurones to the exclusion of others it will tend, other things being equal, to take the same course on a future occasion, and each time it traverses this path the resistance in the path will be smaller. Education then is the laying down of nerve-channels in the central nervous system, while still plastic, by this process of Facilitation along fit paths, combined with inhibition (by pain) in the other unfit paths. He makes the important statement that Facilitation is of great interest in connection with the development of "long paths" in the central nervous system and, *more especially with the acquirement of new reactions by the higher animals.* (Italics not in the original).

Raw Materials of the Central Nervous System.

The raw materials of higher central nervous systems are furnished even in lowly Vertebrates by the neurones and their processes, and the pathways into the grey matter by the "canalizing force of habit" in the receptors and afferent fibres. Facilitation, discovered in higher Vertebrates, such as dogs and cats, throws backwards a light on the earliest struggles towards success and integration among phyla, sub-phyla and smaller groups, and here again the well-known may lead to the less-known. We may then

frame a legitimate hypothesis, or at least an ideal construction of trials and errors and success, if those of lower levels were ever to be introduced to the career of progress and achievement. But to make good this claim it is necessary that it be based on the important doctrine taught by Hughlings Jackson of the three (or more) levels of sensori-motor arcs—those of the spinal or lowest, of the sensory or intermediate, and those of the third or highest level, in which the association-areas of the Primate brain are at once the means and the title to his primacy, or headship of the sentient world. The light of this doctrine guides the mind backwards to the frog-stage of animal evolution with its highly organized congenital system of arcs of the spinal level, so efficient for its life that, even when the brain is removed, the frog can execute under certain stimuli a purposeful complicated movement such as that of trying to wipe away with its foot an irritant drop of acid applied to its head or back ; or, still more, if touched lightly between the scapulæ, will “lower its head at the first touch, and again more so at a second, and at a third will, besides lowering the head, draw the front half of its trunk slightly backwards ; at a fourth the same movement with stronger retraction ; at a fifth give an ineffectual sweep with its hind or fore-foot ; at a sixth a stronger sweep ; at a seventh a feeble jump ; at an eighth a free jump, and so on.” Probably such an animal as the frog has all its reflexes congenitally organized, whereas a dog, reaching the sensory level, has added countless reflex-arcs to those inherited from its early ancestors of the Insectivores which had long emerged from the spinal level, retaining its old, perfecting its new inheritance, and eliminating the unfit. Perhaps a faint picture of this long process may be afforded by watching an experienced mountain guide ascending an ice-slope with the aid of ice-axe, hand and foot.

Integration of Raw Materials.

Every group of animals in the higher ranks has its own entailed property of innate reflexes, for example, the reflexes which subserve the reflex functions of the cord : those of locomotion, muscular and vascular tone, micturition, defæcation, impregnation and parturition. These exist in an animal of the spinal level whether or not it remains purely aquatic, partly aquatic, partly terrestrial, arboreal or terrestrial. As the progressive groups ascend the ladder of life they add to this inalienable heritage, gained we need not here ask how, fresh reflex-arcs by response to new initial stimuli, forging them by the incident of use. So, the original acquirements in the past levels serve as starting points for raising the degree of their

nervous integration with growing control over their environments. The long story from the simple central nervous system of a fish, with a few or no association-areas, to that of man with his extensive frontal, parietal, parieto-occipital association-areas, could never be deciphered, even with the light of the laws of genetics turned on full, without a protracted process of construction of fresh arcs. A common illustration of such a series of changes and results may be seen in the building of a house. Bricks, foundation-stones, walls and a roof may serve some of the elementary requirements of a house and much less than these were of use to early man for his shelter. Without them we cannot call any structure a modern house; but also without floors, staircases, windows, chimneys, division into rooms, some degree of decoration by paint or paper, and a supply of water, we should refuse in these days the name of house to that rough structure, apart from beauty of design, decoration, within and without, and some addition of modern appliances of comfort and convenience. In the history of house-building the stages of supply of raw materials, adaptation to needs guided by selection, initiation, trial and error have their counterpart in the construction of higher animals.

Evidence.

It will be asked what evidence there is for the view here put forward that such is the order and method of the construction of the central nervous system. There are two classes of evidence. The first direct, and the second indirect and resting on inference. The well-known leads to the less-known and inferred. Direct evidence of the foundation of new reflex-arcs and their organization is of course small. The conditions, such as the duration of human life, preclude any extensive formation under experiment of new reflex-arcs, but enough is known to enable one to follow the backward way with some confidence. As to the inheritance of these, the evidence rests on opinion and tremendous probability, but as the only problem with which I am concerned here is that of initiative I think it better to leave the matter of transmission to a dispassionate consideration of the probability of its occurrence.

Direct Evidence.

The prolonged researches of over twelve years of Professor Pawlow and his colleagues on dogs afford a body of evidence as to the possibility of producing new reflexes in the life of an individual which have never been questioned. In 1913 at Groningen, before the International Congress of Physiologists, he gave a brief account

of this work. His previous work on the digestive glands carried on by delicate operations in which the œsophagus was diverted from the stomach and made to open externally, and in which a portion of the stomach was diverted from the rest and a new "small stomach" was formed, gave him the opportunity of immensely important insight into the factors governing the work of the various glands of the stomach. The work of others showed similar results in the pancreas. I only refer to these because they lead up to the special artificial results with new reflexes which he described in 1913. He states that the nervous system besides the primitive function of reproducing innate reflexes, possesses another prime function—namely the formation of new reflexes; and that the living thing is enabled to respond, by definite and suitable activities to agencies to which it was formerly indifferent. His experiments on the formation of "conditional reflexes," as he calls them rather than "acquired" as opposed to "innate," are grouped around the feeding of the animal and mainly deal with the salivary glands, because they are in direct connection with the external world and their reactions are simply and easily observed. An indifferent stimulus is chosen for the reflexes which it is desired to build up, and this is applied at the same time as food or acid is introduced in the mouth. After a few sittings it is found that this indifferent stimulus *alone* is now capable of calling forth a secretion of saliva. "The conditional reflex has been formed; the formerly indifferent stimulus has now found a path to the requisite part of the central nervous system. The reflex-arc has now a different afferent neurone." He gives a good example of this in the result of the application of painful stimuli by a strong electrical current to the skin, systematically accompanying each feeding of the animal. He finds that the strongest electrical stimuli applied to the skin give rise merely to the "feeding reaction," that is, the secretion of saliva, and no indications of any fright or pain appear. "The skin of a dog can be subjected to cutting, pinching or burning, and the only result we shall obtain will be the manifestation of what, judging from our own experience, we should call the symptoms of the keenest appetite; the animal follows the experimenter about, licks himself, and saliva flows in abundance." This, it must be remembered, occurs in the absence of the offer or sight of food, *at the time in question*. He adds: "In this way we have been able to divert the impulses from one path to another according to the conditions, and we cannot avoid the conclusion that the diversion of an impulse from one path to another represents one of the most important functions of the highest parts of the central nervous

system." The presence of certain special conditions, he points out, causes the indifferent stimulus, which would otherwise be dispersed in the higher centres, to be directed to a particular focus, and *eventually to lay down for itself a path to that part*. A very interesting detail of such a building of a new reflex is that "the stimuli from which the new reflex is to be worked out shall be rigidly isolated." Therefore to avoid any interference with the certainty of the experiment, such matters as a personal bodily odour or kind of movement, or even such a slight fact as a change in the mode of breathing familiar to the dog on the part of the experimenter, has in the latest experiments been removed by the application of the stimuli by mechanical devices worked from another room, with results similar to the earlier ones. Conditional reflexes can also be obtained from stimuli arising from the locomotor apparatus, as the joints, eliminating the stimuli arising from the skin. Also certain parts of the frontal lobes were extirpated and "when one part is extirpated the reflex is obtained from the flexion of the joint, but not from the skin; if a different part be removed we can get the skin-reflex, but not the reflex from the joint." He extirpated in one case the greater portion of the posterior part of the brain and the dog lived for several years after this in complete health. It was found easy to obtain a conditional reflex for various intensities of illumination, also for sound, and even a fine differentiation of tones. In another dog the anterior half of the brain was removed and all the reflexes before worked out in this animal disappeared, and yet in this helpless condition of the dog he could train it to give that response of the salivary glands which he called the "water-reflex," in which first of all an irritating acid was introduced into the mouth and the subsequent administration of water provoked an abundant secretion of saliva which does not occur when water is poured into the mouth of a normal dog. This was confirmed in another example in which alone the centre for smell had been spared, and yet it was possible in it to train the smell-reflexes also. I add one striking sentence from Pawlow's address which, though an opinion, must be received with the respect it deserves from such a source. "It is perhaps not rash to think that some of the newly-formed conditional reflexes can be transmitted hereditarily and become unconditional thereby."

Indirect Evidence.

From these limited but cogent pieces of evidence I turn to the larger but confirmatory lines of indirect evidence and inference, of which such works as those of Professors Sherrington, Bayliss, and Starling, the notable address of Professor Macdonald at Portsmouth

in 1911, as well as the recent work of Professor Woods Jones on Arboreal Man, are full. Indeed if the construction of new reflexes and reflex-arcs in organic evolution "forged by an incident of use" as Professor Macdonald puts it, were expunged from these works, their treatment of the physiology of the central nervous system of higher animals would be emasculated, to say the least of it. And yet not one of these eminent men is writing *ad hoc*, or for the confusion of Weismann and his followers. At this point it may perhaps gain for the remaining pages a little more consideration from opponents if I give a few quotations from these writers in support of the foregoing statement—perhaps the breeze of authority may then carry my little bark a little further on its perilous voyage. Professor Sherrington remarks on the first page of his well known work, in reference to the cell-theory, "with the progress of natural knowledge, biology has passed beyond the confines of the study of merely visible form, and is turning more and more to the subtle and deeper sciences that are branches of energetics. The cell-theory and the doctrine of evolution find their scope more and more, therefore, in the problems of function, and have become more and more identified with the aim and incorporated among the methods of physiology." Again, "Mere experience can, apart from reason mould nervous reactions in so far as they are plastic. The 'bahnung' (or facilitation) of a reflex exhibits this in germ." He uses more than once the pregnant phrase, "The canalizing force of habit"; again, "Progress of knowledge in regard to the nervous system has been indissolubly linked with the determination of function in it." Speaking of the receptive-field he says of the central nervous system, "To analyse its action we turn to the receptor organs, for to them is traceable the initiation of the reactions of the centres"; of the extero-ceptive field he says, "facing outwards on the general environment it feels and has felt for countless ages the full stream of the varied agencies for ever pouring upon it from the external world," page 20, and "each animal has experience only of those qualities of the environment which as stimuli excite its receptors, it analyses its environment in terms of them exclusively. The integration of the animal associated with these leading segments can be briefly with partial justice expressed by saying that the rest of the animal, so far as its motor machinery goes, is but the servant, of them. Volitional movements can certainly become involuntary, and conversely, involuntary movements can sometimes be brought under the subjection of the will. From this subjection it is but a short step to the acquisition of co-ordinations which express themselves as movements newly acquired by the individual," and,

"The integrating power of the nervous system has, in fact, in the higher animal more than in the lower, constructed from a mere collection of organs and segments a functional unity, an individual of more perfected solidarity," also "a single momentary shock produces in the nervous arc a facilitating influence on a subsequent stimulus applied even 1400 σ later." I will give but one more statement from this work which seems to tell against my humble position of initiative in evolution. Professor Sherrington says at the end of his book, speaking of the adjustments of nervous reactions in the lifetime of the individual: "These adjustments though not transmitted to the offspring yet in higher animals form the most potent internal condition for enabling the species to maintain and increase in sum its dominance over the environment in which it is immersed." A little care in reading the foregoing chapters will show that this in no way contradicts the views expressed.

Facilitation.

From Professor Starling's Principles of Human Physiology I may again quote part of his account of Facilitation or "Bahnung." "When an impulse has passed through a certain set of neurones to the exclusion of others it will tend, other things being equal, to take the same course on a future occasion, and each time it traverses this path the resistance in the path will be smaller. Education is the laying down of nerve-channels in the central nervous system, while still plastic, by the process of 'Bahnung' along fit paths combined with inhibition (by pain) in the other unfit paths. Memory itself has the process of facilitation for its neural basis," again, "stimulation of one anterior root produces no definite movement of a group of muscles, but partial contraction of a number of muscles which do not normally contract simultaneously. Thus, stimulation of a sensory nerve may provoke either flexion or extension of a limb, not both simultaneously. Stimulation of the motor roots will cause simultaneous contraction of both flexor and extensor muscles. It is *this subordination of morphological to physiological arrangements* in the limbs which has necessitated the foundation of limb-plexuses." (Italics not in the original). Professor Graham Kerr in his work on Embryology before mentioned says: "In early stages of Evolution, whether phylogenetic or ontogenetic, we may take it that vital impulses flitted hither and thither in an indefinite manner within the living substance and that one of the features of progressive evolution has been the gradual more and more precise definition of the pathways of particular types of impulse, as well

as the transmitting and receiving centres between which they pass. We may then regard the appearance of neuro-fibrils within the protoplasmic rudiment of the nerve-trunk as the coming into view of tracks, along which, owing to their high conductivity, nerve-impulses are repeatedly passing. It may be that as each successive passer-by causes a jungle-pathway to become more clearly defined so each passing impulse makes the way easier for its successors and makes it less likely for them to stray into the surrounding substance (p. 112).

Professor Macdonald, in the Portsmouth address referred to, speaking of the states of the cells under excitation, rest, and inhibition, says "*excitation* is associated with an increase in pressure of certain particles within the cells ; in *rest* these particles are in their normal quantity and have their normal number. During *inhibition* they are decreased in number or have a retarded motion. Thus it happens that the excited cell tends to grow in size, on the other hand the inhibited cell tends to diminish, and the resting cell to remain unaltered in the nervous system. Structure is everywhere the outcome of function." Speaking of the relationship of parts within the nervous system, "In so far as it is fixed, it is a sign of the orderly action of circumstance upon the structures of the body, and the result rather than the cause of the monotony of existence. I hold it as probable that all the individual structures of the nervous system, and so in the brain, have just so much difference from one another in size and shape and in function as is the outcome of that measure of physical experience to which each one of them has been subjected ; and that the physiological function of each one of them is of the simplest kind. The magnificent utility of the whole system, where the individual units have such simplicity, is due to the physically developed peculiarities of their arrangement in relation to one another, and to the receptive surfaces and motor-organs of the body." As to the lens-system of the eyeball he remarks, "Surely there is no escape from the statement that either external agency cognisant of light, or light itself has formed and developed to such a state of perfection this purely optical mechanism, and that natural selection can have done no more than *assist* in this process." He applies the same conclusion to the formation of the sound-conducting and resonant portion of the ear as well as the semi-circular canals and to the cerebellum. These statements are not strictly associated with this chapter but bear by analogy very strongly on the matter at issue. Indeed the whole of this address might be utilised by a junior counsel for Lamarck if he rested alone on the authority of a leading physiologist. The same may be said

of the anatomist whose *Arboreal Man* has attracted so much attention. Speaking of the arboreal habit in the phylogenetic history of mammals he asks the question, "How did this factor enable that particular stock to acquire supremacy?" and says that it will be answered as far as it is possible, by the study of the influence of the arboreal habit upon the animal body; which may be put in another way as the production of reflex-arcs suited thereto (p. 3.) Of the muscle groups of fore and hind limbs he says, "With a simple arrangement of anatomical parts a slight shifting of muscular origins has turned a perfectly mobile second segment into a supporting segment constructed upon very simple lines: that these changes are those produced by the demands of support from the hind-limbs in tree-climbing seems obvious" (p. 6); of the position of uprightness upon a flexed thigh of an arboreal man, "It is tree-climbing which makes this posture a possibility" (p. 63). "But it is not to be doubted that the underlying principle is clear enough, that the arboreal habit develops the specialised and opposable thumb and big toe" (p. 71). "Even before the power of grasp is developed, we may imagine the dawn stages of educational advances initiated by hand-touch" (p. 159). "Tactile impressions gained through the hand are therefore perpetually streaming into the brain of an arboreal animal and new avenues of learning about its surroundings are being opened up as additions to the old factory and snout-tactile routes" (p. 160). He asks also the pertinent question, and says at least a partial answer to it can be given, "Did the cerebral advance create the physical adaptations, or did the physical adaptations make possible a cerebral advance?" (p. 196). Two more statements from this chapter show what the answer to this question from the *anatomist* would be—"and again in the evolutionary story we are forced back to consider a combination of seemingly trivial, and apparently chance associations: in this case the dawning possibilities of neo-pallial developments combined with the physical adaptations *due directly to environmental influences*" (p. 198). I have ventured to underline this passage.

I regret the necessary length of these quotations but, on account of them, can the better be suffered to finish this study, when I briefly consider certain well-known nervous reactions in the cat and dog as to their probable origin. It would be a highly interesting thing to hear an exposition by an expert of all the reflexes and reflex-arcs of such a system as those which in a cat, dog, ape, or man are concerned with the passage of a morsel of food from the mouth through all its chequered and varied career till it undergoes metabolism and excretion, but I could not do it if I would, and would

not here if I could, because of their fundamental fixed and innate character, and I think it simpler and safer to refer to such minor reflex-arcs as those which govern the scratch-reflex in a dog, the pinna reflexes in a cat, and a few smaller ones, on the principle of *ex uno disce omnes*. Such minor nerve-mechanisms as these in a pair of well-known domesticated animals will suffice for evidence on behalf of initiative in evolution.

The Scratch Reflex.

The scratch-reflex in the dog, which like the tendon-reflex in man was in my youth a subject for schoolboy tricks, has received a vast amount of attention and research from physiologists to whom it has brought valuable fruit. It is a familiar phenomenon in a familiar friend of man. There is a saddle-shaped area on the back of the dog over which it was found empirically that even a light stimulus when applied rhythmically, produces the "scalptor-reflex" or a reflex rhythmical action of the flexor muscles of the leg on the same side, calculated to remove the irritating causes of the stimulus. This includes a series of receptors in the skin leading to a spinal segment in the region of the shoulder, a long neurone in the cord, then a motor neurone, the axon from which activates the flexor muscles of the leg and produces scratching. It is described as an efferent arc from receptor to the motor neurone, from which the Final Common Path supplies the motor apparatus or effector. Professor Sherrington says that in this reflex a single stimulus which is far below threshold intensity is found on its fortieth repetition and nearly four seconds after its first application to become effective and provoke the reflex and that its frequency is about 4.5 per second. The reflex movement remains rhythmic and clonic under the strongest as under weaker stimulation. When it is easily elicitable the scratch-reflex can be evoked by various forms of electrical as well as mechanical stimulation, but, when not easily elicitable, electrical stimulation fails whereas rubbing or other mechanical forms of stimuli still evoke it, though less vigorously than usual. This reflex can also be set aside by the "nociceptive arc from the homonymous foot" or, in other words, a nocuous stimulus to the leg of that side produces "interferences which amounts to inhibition." Empirically it is easy to notice also that if the "scalptor-reflex" can be elicited on both sides of the body, the dog when standing will momentarily lose the power in the hind legs.

Note.—The rhythm of this reflex act is so special even to the layman that lately I had a singular confirmation of its stereotyped

character, when lying awake at night and being puzzled by a curious rhythmical scratching sound coming from my next door neighbour's back yard. It might have been taken by a wakeful person for some mechanical work on the part of a burglar, but after listening repeatedly to the apparently familiar sound I found that it came from the kennel of a fox terrier kept by my neighbour.

Purposes of Reflexes.

All reflexes being purposive this particular innate reflex is acknowledged to have for its purpose the grooming or cleaning of the skin over its hereditary territory. This introduces its connection with initiative here propounded, and the justification for its introduction is contained in Professor Sherrington's statement that "In the analysis of the animal's life as a machine in action there can be split off from its total behaviour fractional pieces which may be treated conveniently, though artificially, apart, and among these are the reflexes we have been attempting to decipher"—scratch-reflexes and others. There seems to be no reason for the existence and stereotyped character of this reflex except the need or rather the desire (if one may use a convenient but inaccurate term) on the part of the dog to remove an irritant which disturbs its comfort when at rest. Some "minor horrors," probably fleas moving across the skin-receptive field of its shoulder and back, must be assumed to be the irritant in question. This touches the great question of the initiative of this remarkable reflex, which seems more fixed and powerful in the dog as we know him than that other reflex which leads him to turn tail and flee immediately he sees a boy stoop down as if to pick up a stone. I dare say a clever advocate on the opposite side might impress a jury by building up a case under which an adaptation to a protective need would be conceived as responsible for the rapid flight at the sight of the threatening attitude of the boy. Such a reconstruction is not required, for it is perfectly clear that in the history of the domesticated dog the selection of such an adapted reflex could have no place. The survival-value of this reflex would be nil, for the number of dogs killed by a stone or maimed for life would be so negligible that the production of a specialised reflex for the purpose by selection or survival of the fittest would not arise. Obviously the danger would be intermittent and rare; and dead dogs tell no tales. On the other hand it would be highly unpleasant for dogs to be hit by stones and educability would lead them to avoid the stooping attitude associated with missiles.

We are told on high authority that not education but educability is transmissible, and yet this humble reflex appears in very young dogs that could hardly if ever have known the impact of a stone. Incidentally we are compelled to remember how in past battles of our youth the aim both of "ourselves and the enemy" was deplorably poor, and not from want of practice. This school-boy-stone reflex is either an example of educational effects transmitted or of a minute bit of the unpacking of an original complexity which it would require the brain of a de Quincey to work out. But if we suppose the initial stages of such a stimulus as the occasional impact of a stone in many generations to be slowly ingrained in the skin-receptors, reflex-arcs and receptors we do not need opium either for the acceptance of orthodox dogma or to aid us in the Mendelian alternative to a very simple ideal construction.

This digression bears on the initiative of the more important scratch-reflex, and it is profitable to ask "are not both of these reflexes in dogs examples of Evolution of the Indifferent?" Is it possible to imagine that from its inception to its fully-formed state, with a specialised territory of skin-receptors accurately mapped out, with receptor neurones, reflex-arcs and adapted effectors, this scratch-reflex can have arisen through Germinal Selection or selective processes within the germ? At no stage can anything more than a contribution to more or less comfort to the animal be held to result from its operation. It is strangely reminiscent of the proceedings of an elderly man after lunch on a hot day when he protects his head against house-flies with a handkerchief. I am aware that it is but one of a large number of reflexes produced for the purpose of grooming the trunk head or limbs of animals as low down in the scale as the house-fly or grasshopper, many of which were beautifully described a few years ago by Miss Frances Pitt in the *National Review* in an article dealing with small mammals, chiefly rodents. But I have availed myself here as elsewhere, of the liberty of doing what Professor Sherrington says we may do, and consider this scratch-reflex as split off from the rest of the animal's behaviour for the purpose of analysis. He also says in discussing the subject of parasites moving across the receptive surface of the skin that the ulterior purpose may be the removal of what "would confuse its function as a receptive surface to more significant environmental stimuli." This statement is hypothetical and the problem obscure; but at any rate we know this that the removal of the parasite must conduce to the greater comfort of the dog without any more recondite purpose. The one suggested by Professor Sherrington would in some possible but very vague

manner be referable to selection, but, whether the suggestion be valid or not, it is almost impossible to suppose that a saddle-shaped area of the kind described could be under the guidance of selection. The law of Parsimony forbids. There is a close similarity between this saddle-shaped area in the dog and that on the cow's trunk described in Chapter X. It is difficult to believe that from man downwards to grasshoppers relief from mild irritating causes such as this is not enjoyable to the particular animal, and yet indifferent altogether as to its survival in the struggles of life for food and mates. The "scalptor-reflex" only reaches the limits of the receptive field of the scratch-reflex and it is contrary to observed facts that parasites confine their depredations just to the region where the formidable scalptor-reflex can reach. The wicked flea knows better than that. The initiative of this reflex can well be pictured as taking place in domesticated dogs and their wild ancestors whose habitats in prehistoric times were probably infested with these irritants to such a degree that no modern mind can conceive, and the adequate stimuli, leading to receptors after ages of impact and consequent hammering out pathways through certain reflex-arcs until the required weapons of offence or effectors were organised into a *defensive-offensive system*—were there in profusion. But a great and fundamental principle of the evolutionary process such as Selection is not honoured by being dragged in, even for forensic purposes, to account for results which owe to the search for comfort their perfection of organisation. I have personally seen in some professional invalids of the softer sex nearly as perfect adaptations to their comfort which in no way contributed to their length of life. This may be put aside as irrelevant but it is at least suggestive.

I submit the statement as to the scratch-reflex in the dog that from beginning to end it is an *indifferent* mechanism and the probability is immense that its initial stages were governed alone by repeated stimuli from parasites which produced receptors, conducting fibres afferent neurones and efferent neurones, leading into the Final Common Path controlling the flexors of the hind limb. It would then come under the Law of Subjective or Hedonic Selection formulated by Professor Stout in the words: "Lines of action, if and so far as they are unsuccessful, tend to be discontinued or varied; and those which prove successful to be maintained. There is a constant tending to persist in those movements and motor attitudes which yield satisfactory experiences, and to renew them when similar conditions recur; on the other hand those movements and attitudes which yield unsatisfactory experiences tend to be

discontinued at the time of their occurrence, and to be suppressed on subsequent similar occasions."

In this connection a statement from Professor McDougall's work may be advantageously quoted. He says that "It is characteristic of those (arcs) of the higher or third level that their organisation, their interconnections, by means of which the simpler neural systems of great complexity, is *congenitally determined in a very partial degree only*, and is principally determined in each individual by the course of its experience. The arcs of the higher level thus constitute the physiological basis or condition of docility, the power of learning by experience."¹ (My italics)

Scratch Reflex of the Cat.

There is a notable difference between the scratch-reflex of the dog and that of the cat, especially as to the site of its receptive-field. That of the dog has been referred to, but it appears to be generally accepted that the cat has no such saddle-shaped or indeed other area of skin receptive-field on its back or flanks. I have repeatedly tried by various mechanical stimuli, applied both irregularly and rhythmically, to evoke a scratch-reflex in a cat, young or adult, on the surface corresponding to that of the dog, and have found no response. This has been tried both when the animal was awake and when asleep. But the receptive field of the cat's scratch-reflex has received careful and elaborate attention, which is described in a paper by Professor Sherrington in the *Journal of Physiology*, Vol. LI. No. 6. By means of delicate stimuli, mechanical and electrical in a decerebrate cat, the receptive-field of the scratch-reflex has been accurately delineated in the pinna, and several other pure reflexes have been obtained. These are protective of the pinna; some, the retraction and folding reflexes seem directed against irritant touches, *e.g.* the settling of fleas—or against exposure to injury in fighting; others, the cover and head-shake and scratch-reflexes against the ingress of foreign matter, such as dust, water, insects, into the meatus and ampulla. The threshold for their elicitation is extremely low, that is to say, they require very gentle stimuli to evoke them, while with the exception of the scratch-reflex they are elicited with difficulty and uncertainty *by electrical stimuli* (My italics) to which the animal has been subjected in the course of its total experience. He adds that the pinna reflexes are readily obtained in the normal animal, and I may allude here to some small observations I made on a normal young cat

¹ *Op cit.* p. 21.

during profound sleep, recorded in *Nature*, Vol. 106, Sept. 2, 1920. Light mechanical stimuli, applied during this state of deep sleep to the internal surface of the pinna, especially close to the meatus, produced first, twitching of the facial muscles on the same side; second, as this ceased the fore foot was moved irregularly towards the ear, and third, as this ceased a rhythmical scratching action of the hind foot took its place, the rate of which seemed to be exactly the same as that of the scratch-reflex in the dog evoked from stimulation of the flank and back. I had not then, unfortunately read more than an abstract of the above paper, but if the full account be followed it will be seen that the various "territories" belonging to all the former-reflexes are now known as well as the frontiers of a European Kingdom. All I was able to do with this unusual opportunity of a heavy sleep in a normal young cat was to verify more roughly Professor Sherrington's observations and slightly to extend them *in respect of a sleeping animal*.

In the course of these observations on a young cat I examined the various regions of the back and flanks with mechanical stimuli of different degrees of strength. These were applied during sleep and I found that it was more often during a moderate than a light or deep sleep that the following results were shown—chiefly under the stronger stimuli the tail was raised sharply and swept in a circular way, and this would be repeated according as the stimulus was applied; but at the same time there was shown a strong, irregular twitching along the flank, extending forwards to a point near the level of the shoulder. This latter reflex would appear to be a reaction on the part of the panniculus carnosus. Both the reflex of the muscles of the tail and this of the flanks appear to be connected in their origin with movements of parasites in their respective territories.

In considering the scratch-reflex in the cat a subtle bit of adjustment is found. That coarse and simple scratching of its ear, which we see so often in the cat, must have often astonished us for its vigour and yet its bloodless character. This action is of course a purposeful one, for it goes on when the animal is awake. Here if anywhere this profoundly hedonistic animal shows that for it the laws of comfort are its laws of conduct. It is clear that there may be two processes or conditions involved in its bloodless violence. On the one hand the reflex retractile mechanism of the claws may be kept in abeyance by another reaction which is prepotent; on the other, it is a fact that the hind foot in the cat is furnished with claws which are much blunter than those of the fore foot. As far as I have been able to examine cats of different

ages I have found the claws of the hind foot more like the blunt claws of a dog than the familiar sharp claws of the Felidæ. So in the violent scratching referred to there may be a double reason associated in the process. As to the difference in the sharpness of the fore and hind claws it would appear to be remarkably like a transmitted bit of adaptation initiated and kept in being by use and habit in progression, for the hind foot in such animals as the cat has a larger share in this action than the fore foot. But here it is difficult as so often to assign to selection its possible share of the adjustment.

Certain minor but persistent reflexes may be briefly mentioned in support of this side of the evolutionary process. In the dog and cat, as we know them, the action of the muscles of the tail by which it is elevated during the act of defæcation is very suggestive of a reflex acquired by a very small degree of physical comfort and repeated in countless individuals, wild and domesticated. I have seen not only this but a few small scratches made by a cat before defæcation in a kitten as young as three weeks old. It is also mentioned in illustration of a vestigial character that a horse will paw the ground with no immediate apparent object, the act being derived from ancestors which thus cleared away snow from the ground. This is claimed, doubtfully I think, as a vestige of a formerly *useful* habit but seems more probably to be one of these indifferent reflexes connected with comfort than with survival-value.

It will be observed that in this branch of the case for Lamarck *v.* Weismann the indirect evidence from inference far exceeds in amount that of direct experimental evidence, but from the nature of the problem under consideration this could not be otherwise.

If we may again look back in thought over the long series of animals, from man downwards, we shall picture those of the spinal level striving (with apologies for the use of an anthropomorphic word) to reach the sensory level and finding out the fact that few there be that enter therein. Again we see in vision the higher creatures of the sensory level reaching forwards to the strait paths of primate existence, and again finding the difficulty of self-advancement that their predecessors found. We see the elect few of these, by a happy combination of nature and nurture, uprearing to glory and honour the primate stock with its culmination in man. A long vista indeed and a vision, but assuredly no mere figment of the imagination, as some of the slender facts and arguments here would seem to show. With Professor Bateson we personify

Nature in the story, with her wonted coyness betraying the fact that though she is stern she has her tolerant moods ; that she allows her children, even that "insurgent son" who calls himself *Homo Sapiens*, a genial liberty to frame new reflex-arcs which make for his enjoyment of life in indifferent fields, and *that the great neural process of Facilitation is the leading factor in their constructions and probably also in more deeply-based systems of sensori-motor arcs.*

SUMMARY.

Though it be true that *dolus latet in generalibus*, it is a more important truth that “without premature generalisations the true generalisation would never be arrived at.”¹

Therefore I conclude :—

1. That Plasto-diēthēsis, or the moulding and sifting processes experienced by organisms, represents the beginning and end of higher animal evolution ; and that its wide hyphen stands for the provinces where Mendelism, Mutationism, Tetraplasty, Orthogenesis, and the dynamical work of growth on Form, as well as other factors yet to be discovered, can range at large.
2. That personal selection is the leading form of that process in higher animals, whereas among Invertebrates, especially unicellular forms, selection of groups is the rule.
3. That Initiative in animal evolution comes by stimulation, excitation, and response in new conditions, and is followed by repetition of these phenomena until they result in structural modifications, transmitted and directed by selection and the laws of genetics—a series of

¹ Herbert Spencer, *Essays*, II, 57.

events which agree with Neo-Lamarckian principles.

4. That undesigned experiments in the arrangement of the Mammalian hair, and the production of new bursæ, as well as the designed experiments of Pawlow, support the foregoing claims, with which agree the converging facts of—varieties of epidermis, arrangement of the papillary ridges, flexures of the palm and sole, the formation of the plantar arch, the origin of certain muscles, the innervation of the human skin, and the building of reflex-arcs.
5. That there is a large place in higher animals for the Evolution of the Indifferent through the action of use and habit.
6. That the position for Initiative in Evolution here advanced is no bar to unlimited research.

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